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PHYSICS.—*The Dorsey fathometer.*[1] HERBERT GROVE DORSEY.
U. S. Coast and Geodetic Survey.

The regular type of fathometer (U.S. Patent No. 1,667,540 to the writer), has been used by the United States Coast and Geodetic Survey since 1925 and has proved very valuable in measuring all depths from 15 fathoms to 3,000—the deepest encountered by this Bureau in regular surveying work. This work has all been done by what is called the red light method, in which the depth is indicated by a flash in a rotating neon tube and recorded in the sounding book.

While this type fathometer gave excellent results in depths greater than 15 fathoms, there was need for an instrument of high precision for depths less than 15 fathoms; consequently, in January, 1933, it was decided to develop an instrument primarily for shoal water only, that is, depths no greater than 20 fathoms which would overlap the depths measured by the regular type instrument, and since it is desirable to have a comparatively large number of indications per second it was decided to make the scale from 0 to 20 fathoms and have 20 indications per second, so that there would be indicated a nearly continuous profile of the bottom. In order to get sufficient accuracy, it was decided to use a tuning fork driven by thermionic tubes and drive a synchronous motor from this source. Figure 1 shows schematically the operation of the entire system.

## INDICATOR

The indicator consists of the rotor, the stators and a starting motor to bring the rotor up to synchronism. It was considered desirable that the indicator run at its correct speed or not at all. The rotor is run by current taken from the fork circuit and amplified by a pair of power triodes. A tuning fork can easily be kept on its frequency with an error less than 0.1 per cent, and if temperature control of the fork be used, any desired accuracy can be obtained. The forks

[1] Presented before the Philosophical Society, January 19, 1935. Publication approved by the Director of the Coast and Geodetic Survey of the U. S. Department of Commerce. Received July 8, 1935.

used are made of steel having a low temperature coefficient of modulus of elasticity and temperature control is unnecessary since a change of temperature of 30°C makes only about 0.1 per cent change in frequency. By using a frequency of 1025 cycles per second and a stator without polarizing current, a synchronous motor having 100 teeth on the rotor will rotate at a speed of 20.5 revolutions per second.

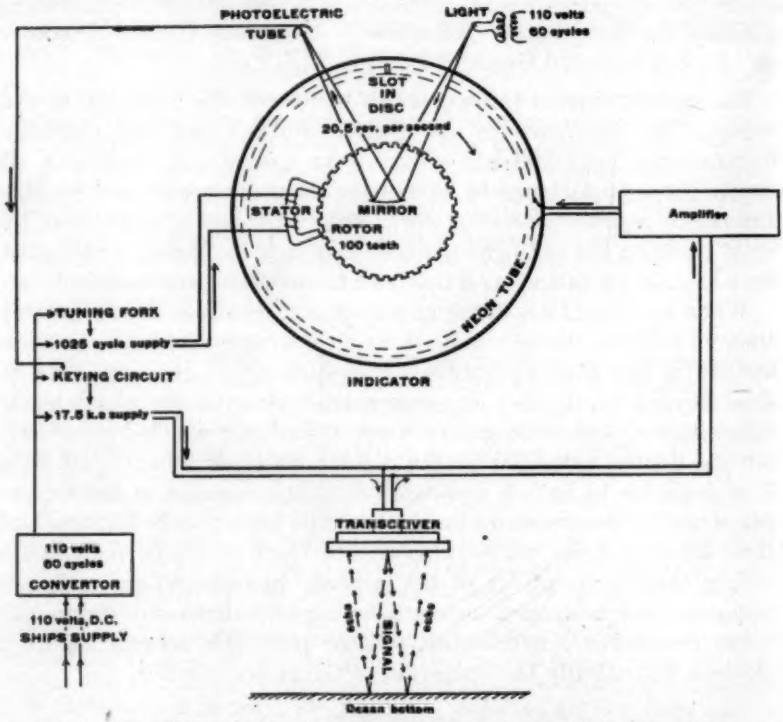


Fig. 1.—The Dorsey fathometer, schematic diagram of method of operation.

An annular space in the rotor is filled with mercury to act as a balance. In any method of controlling speed by a governor no correction to the speed can be made until the speed has changed, whereas, with a tuning fork the regulation is almost continuous. With this fork frequency the velocity of calibration is 820 fathoms, or 1499.6 meters, per second. On the same shaft with the rotor is a disk having a narrow radial slot and just back of this disk is a neon tube bent in the form of a circle of 7 inches inside diameter, so that when the neon tube is ionized it will be seen through the slot in the disk. The dura-

tion of this flash is probably not over 2 or 3 millionths of a second, resulting in a brilliant red flash so brief that the slot appears stationary and for a constant depth the indication is so steady that it can be viewed through a magnifying glass and the variation on the scale is less than 1/32 inch. In front of the disk is a glass scale calibrated to 20 fathoms, the fathoms being subdivided into feet. The diameter of the scale is about 8 inches giving a scale length of 25 inches, thus giving 0.2 of an inch for 1 foot of depth or 1.8 centimeters per meter depth for a scale calibrated in the metric system. These divisions can easily be read to tenths so that it is possible to read to tenths of feet or to 10 centimeters on a metric scale. The dial is frosted slightly so that little light is reflected, making the flashes more readily perceptible. At one side near the teeth of the rotor is a small neon lamp, actuated from the 1025 cycle alternating current, giving 2050 flashes of light per second on the teeth, making them appear stationary when the rotor is in synchronism with the tuning fork.

In order to send the signal, contacts were found unreliable, due to chattering, so a small concave mirror is rotated on the shaft to reflect light from an incandescent lamp to a photo-electric tube. The tube and lamp are placed on top of the indicator under small hoods. A slot under the photo-electric tube is adjustable, to correct the position of the flash made at the zero of the scale when the signal is produced, so that the readings may indicate surface depth instead of depth under the ship. Figures 2 and 3 show the front and side of the indicator.

## POWER SUPPLY

The electromotive force generated by the flash of light on the photo-electric tube is amplified by a single triode and then changes the grid bias of a thyratron, FG 65, a hot cathode gaseous triode, causing a condenser, with renewable charge, to discharge through the anode-cathode circuit of the thyratron. This discharge current passes through the primary of a transformer, the secondary of which is in the screen grid circuit of a pair of power pentodes in a self-exciting push-pull circuit tuned to a frequency of 17.5 kilocycles. The signal is then amplified by a pair of power triodes in the push-pull circuit and passes to the transceiver. The method of changing the screen grid voltage from about 200 volts negative to 300 or 400 volts positive gives a very short and regular signal. No current is taken by the anode circuit of the tubes until the screen grids become positive, thus economizing the high tension current. This method of

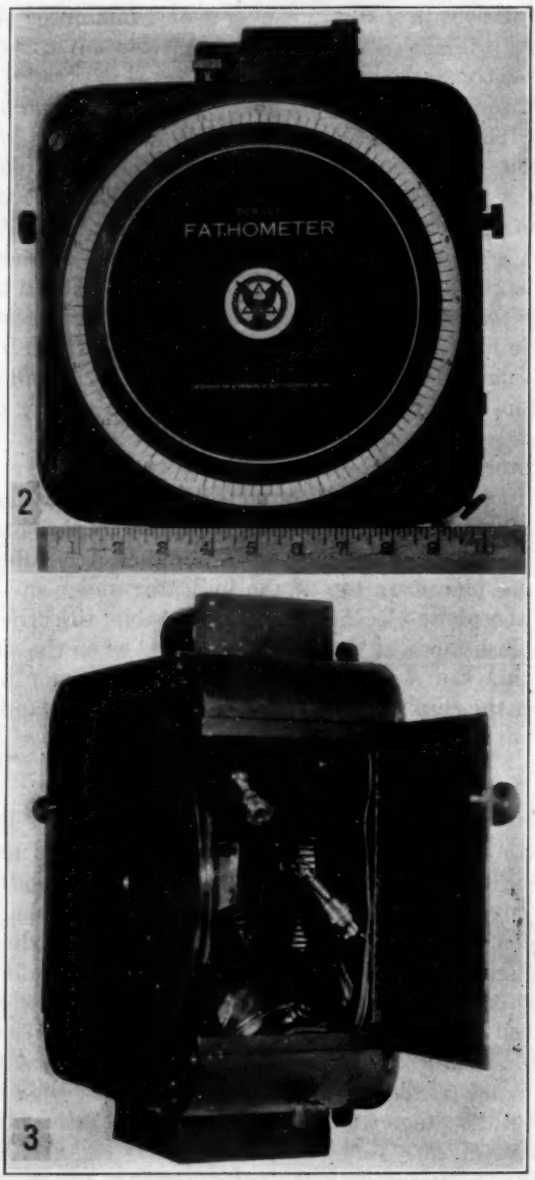


Fig. 2.—Front view of indicator. Fig. 3.—Side view with front removed.

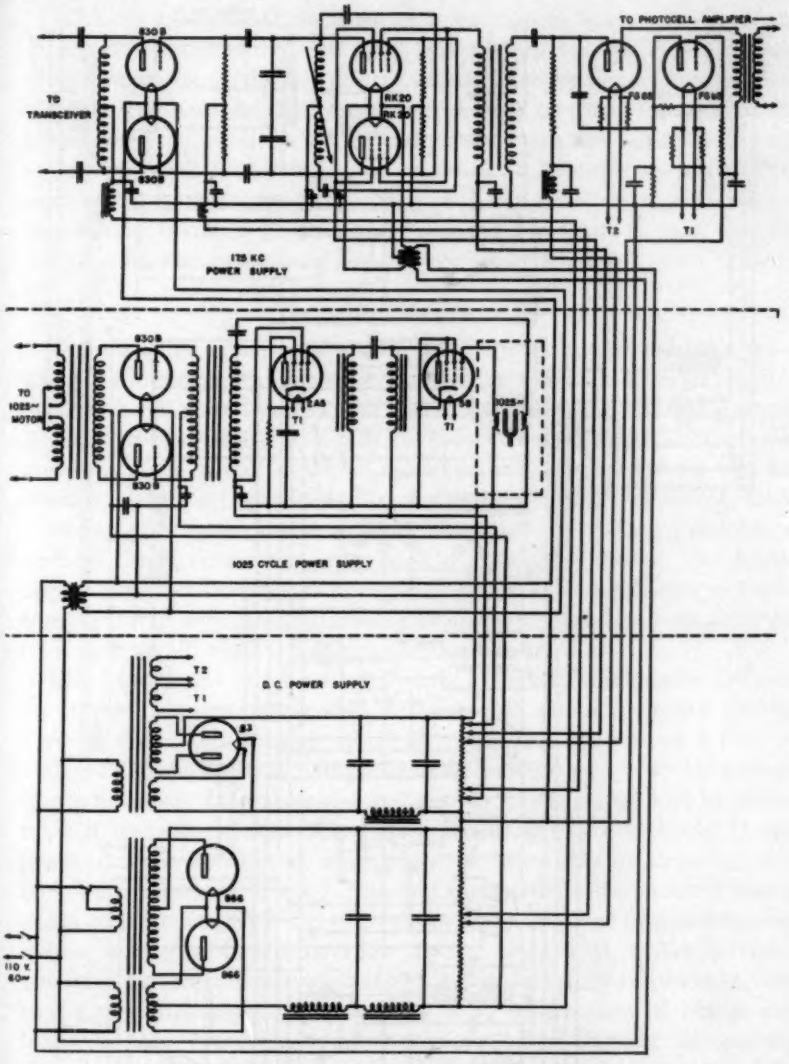


Fig. 4.—Wiring diagram of power supply.

sending the signal has proved very simple and absolutely reliable. With no moving contacts in the indicator, construction and performance are simplified and less energy is necessary to drive the moving parts.

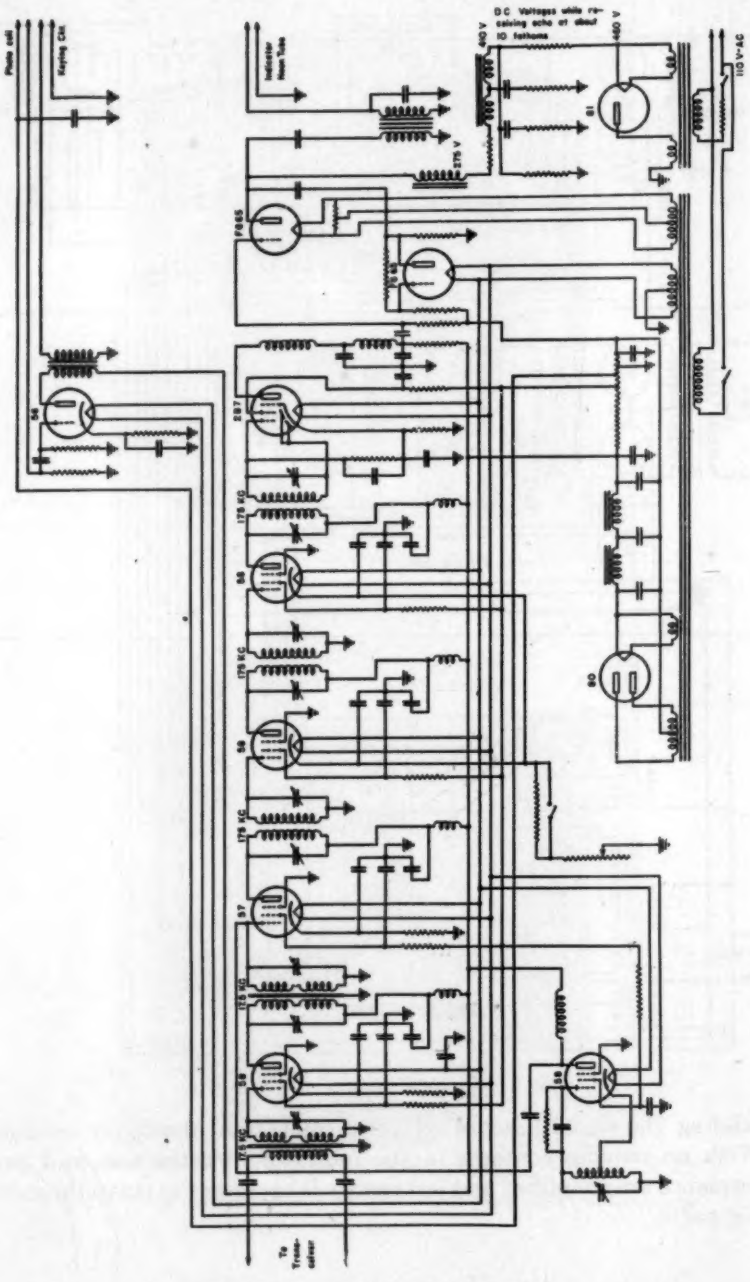

Fig. 5.—Wiring diagram of amplifier.

While it is easier to send on one instrument and receive on another, it was decided to use only one transceiver, so that the scale of the indicator would be uniform throughout; consequently, no matter how shallow a depth is measured, there is no correction due to the longer path required for the sound waves when two separate instruments are used for sending and receiving. Although the difficulties were great at the beginning, the increased effort to use the single transceiver made it worth while to spend the extra time in the development. Figure 4 shows the power supply circuit.

### AMPLIFIER

The amplifier consists of a pair of push-pull triple grid tubes as a preamplifier, after which a superheterodyne circuit is used to amplify on an intermediate frequency of 175 kilocycles, after which the signal is rectified and actuates a pair of thyratrons in series through the anode-cathode circuit of which a condenser is discharged, as was described in the keying circuit. The discharge of this condenser through a transformer generates a voltage of about 700, which produces a flash in the circular neon tube back of the rotating disk. The whole apparatus is so sensitive to changes in depth that the indicator registers the differences in depth when a small surveying ship rises and falls on a light swell. Figure 5 shows the amplifier circuit.

The instrument has been used during the last field season for two months on the surveying ship *Lydonia* and about a month on the *Hydrographer*. The ranges of depth measured were from 5 feet to 120 feet. On the *Lydonia* comparisons were made every day for several weeks between the fathometer indications and the lead line to determine if there were any variations between the two methods. It appears that the fathometer indications are more reliable than the lead line, even when the latter is handled by a skilled leadsman of many years' experience. With the ship stopped, the lead line and fathometer indications agree to within a few inches, or as close as can be read, but with the ship under way, there is always a slight difference, the lead line indicating the greater depth by an amount of about one foot. On the *Hydrographer*, the cross sounding lines of the survey show agreement of depth to a few inches with the fathometer, while with hand leading soundings an agreement to within a foot is generally considered satisfactory work.

During the coming season it is expected to use the fathometers on these two ships again and in addition make an installation on the

Tender *Gilbert* and one on a 75-foot launch to determine its operation on small craft.

In this work the writer desires to express his thanks to his assistants, Charles G. McIlwraith, R. B. Wright and Thomas B. Hickley for their numerous valuable suggestions in the development and untiring efforts in the laboratory and at sea; to wireless operators William Smith and G. D. Nedley for their help in maintenance on the *Lydonia* and *Hydrographer;* to Captain Gilbert T. Rude, Chief of the Division of Hydrography and Topography for his continued keen interest and encouragement and to Captain R. S. Patton, Director of the Bureau for his faith in the ultimate outcome of the development and for the honor conferred in naming the instrument the Dorsey Fathometer.

CRYSTALLOGRAPHY.—*Alternating axes and symmetry symbols in crystallography.*[1] J. D. H. DONNAY, Johns Hopkins University. (Communicated by G. TUNELL.)

It is well known that all thirty-two crystal classes cannot be derived if the only symmetry elements used are the plane of symmetry, the center of symmetry, and the rotation axis of symmetry (or axis of symmetry of the 1st kind). Only thirty-one classes are obtained in that manner, the missing one being the tetragonal disphenoidal (or sphenoidal tetartohedral) class of the tetragonal system. Bravais has often been criticized for omitting this possible crystal class in his celebrated *Etudes cristallographiques;* as a matter of fact, he did recognize the possibility of alternating symmetry as he explicitly states that this concept will be deliberately left out of his treatment. From the practical standpoint, the fact that no substance was known at the time to belong to the tetragonal disphenoidal class might have justified Bravais' attitude. On theoretical grounds, however, alternating symmetry must be introduced for the sake of completeness.

Another reason for using this type of symmetry has been given by Austin F. Rogers[2] who redefined symmetry operations as "movements by means of which each and every face of the general form of a crystal may be derived directly from an arbitrarily selected face." The trend of his argument is as follows: (1) the symmetry operations of a general crystal form $\{hkl\}$ have been proved to form a group; (2) the number $n$ of symmetry operations in the group (or the order $n$ of the point-group) is equal to the number of faces of the general

[1] Received November 23, 1934.

[2] AUSTIN F. ROGERS. *A mathematical study of crystal symmetry.* Proc. Am. Acad. Arts and Sc. 61: 161–203. 1926.

form $\{hkl\}$; (3) by the very definition of a group, the product of any two symmetry operations is also a symmetry operation; hence, (4) in order to emphasize this individuality of each symmetry operation, usually concealed under the symbolic *product* of two *generating operations* or powers thereof, every symmetry operation should be represented by a distinct symbol (in each one of the thirty-two point-groups).

Now, in this scheme, elements of alternating symmetry cannot be dispensed with. Rogers' method gives a truer picture of symmetry relations than that which is based on the use of generating operations, their powers and products. Mathematically, it may not be of any moment to stress the fact that a product of two operations is also an operation by coining a special word to designate the new symmetry operation; such an idealized composite operation (rotatory-reflection or rotatory-inversion) may be considered a very artificial entity being as it is almost always reducible[3] to a product of two simpler operations. Physically, however, the concept introduced by A. F. Rogers has unquestionable significance. A form is defined as the assemblage of all similar (or equivalent) faces; hence, in the general form, any face should be derivable from any other face by means of one symmetry operation only and not in successive steps, inasmuch as, from the physical point of view, there is no justification for privileged symmetry operations (*generating operations*).

Rogers' original application of group theoretical notions to crystal classes throws unexpected light on the nature of crystal symmetry. Not only does it bring out the fact that the polyhedron crystal is carried to self-coincidence by a symmetry operation, it also emphasizes the *equivalence* of the faces (edges and corners, as well) of the general form. The symmetry concept is thereby renovated and enriched.

For the two reasons given in this introduction, the necessity of using alternating symmetry appears undisputable.

## TWO DEFINITIONS OF ALTERNATING SYMMETRY

Crystallographers have defined the operation of alternating symmetry in two different ways: (1) as a rotation followed by a reflection in a plane perpendicular to the axis; or (2) as a rotation accompanied by an inversion through a point lying on the axis. These two composite operations may be termed respectively *rotatory-*

[3] Let us recall here the exception of the tetragonal disphenoidal class where the alternating axis is irreducible.

*reflection* and *rotatory-inversion* or, more concisely, *rotoflection* and *rotoversion*, after Rogers' proposal.

Before going further, the system of notation of symmetry operations and symmetry elements to be used in the discussion must be explained. The symbols are taken from Rogers.[4]

Plane of symmetry: P.

Center of symmetry: C.

Rotation axis: $A_p$; rotoversion axis: $\mathfrak{A}_p$; rotoflection axis: $\mathscr{P}_p$; where the *period* $p$ indicates the value of the angle $360°/p$ through which the crystal is rotated about the axis (the possible values of $p$ are 2, 3, 4, and 6). It should be remarked, however, that a 2-fold rotoversion axis is the equivalent of a plane of symmetry for which the symbol P seems more logical and, similarly, that a 2-fold rotoflection axis is equivalent to the center of symmetry which should preferably be designated by C.

As for symmetry operations, small italics are used: $p$ (reflection), $c$ (inversion), $a$ (rotation), $ap$ (rotoflection), and $ca$ (rotoversion). In the last three symbols, a subscript gives (in degrees) the total rotation performed. The identical operation is represented either by 1 or by the power zero of any operation.

There has been no general agreement as to what operation of alternating symmetry should be used in preference to the other. Some authors have adopted rotoflection, others have employed rotoversion. A. F. Rogers uses both; he departs from Hilton in advocating the use of the rotoflection axis $\mathscr{P}_6$ in the rhombohedral and hexagonal scalenohedral classes of the trigonal subsystem instead of the rotoversion axis $\mathfrak{A}_3$; he represents the symmetry of the trigonal dipyramidal class by $\mathfrak{A}_6$ in contradistinction with Jaeger who uses the rotoflection axis $\mathscr{P}_3$.

Interest in that much debated question is now being revived by the recent adoption, at Zürich, of a system of international symmetry symbols[5] which is based on the use of one type of alternating axes only, the rotoversion axes. The purpose of the present paper is to show: (1) that the symbols $\mathscr{P}_6$ and $\mathfrak{A}_3$ on the one hand, $\mathfrak{A}_6$ and $\mathscr{P}_3$ on the other hand, are strictly equivalent and can be used interchangeably just in the same manner as $\mathscr{P}_4$ and $\mathfrak{A}_4$; consequently, (2) that the reasons for adopting rotoversion axes rather than rotoflection axes are more formal than fundamental, being simply a matter of convenience and harmony in classification schemes.

[4] Similar symbols for the 3-fold alternating axes had to be added, since Rogers only recognizes alternating axes with an *even* period (4 or 6).

[5] MAUGUIN. *Sur le symbolisme des groupes de répétition . . .* etc. Z. f. Kr., **76**: 542–58. 1931.

Alternating axes of crystal symmetry only need be considered here. A complete discussion including non-crystallographic alternating axes has been published by F. Becke.[6]

### EQUIVALENCE OF ALTERNATING AXES

Rogers attempts to rule out the 3-fold alternating axes on the principle that the period $p$ of an alternating axis $\mathcal{A}_p$ or $\mathfrak{A}_p$ should always be even. In the discussion of the trigonal dipyramidal class, for instance, he says: "Since there are six distinct operations involved, the axis is clearly 6-fold and not 3-fold. Three powers of $ap_{120°}$ do not form a group; the six powers of $ca_{60°}$ are required. $\mathfrak{A}_6$ and not $\mathcal{A}_3$ must be used to indicate the symmetry in this class."

It is essential to recognize that *the period of an alternating axis does not necessarily indicate the order of the group of symmetry operations represented by that axis.* The two are different: (1) The order $n$ of a point-group indicates the number of operations contained in the group or the number of faces in the general form. (2) The period $p$ of any axis, whether the axis be of the first sort (rotation axis) or of the second sort (alternating axis), refers to the amplitude $360°/p$ of the rotation performed. The group $\mathcal{A}_3$, for instance, is of *order* 6 although the rotation amounts to 360°/3 in the rotoflection and the *period* of the axis is consequently 3.

When the period of an alternating axis is an even number, such as in the symbols $\mathcal{A}_4$ (or $\mathfrak{A}_4$), $\mathcal{A}_6$, and $\mathfrak{A}_6$, then the *period of the axis* is equal to the *order of the group* represented by the alternating axis. Whether it may not be advantageous to have the order of the group indicated by the period of the axis (when the axis constitutes all the symmetry present) is another question but that this condition should always be fulfilled is by no means required. This point should be kept in mind throughout the following sections.

### EQUIVALENCE OF THE 6-FOLD ROTOFLECTION AXIS AND THE 3-FOLD ROTOVERSION AXIS

In the rhombohedral class of the trigonal subsystem, Rogers writes the symmetry operations of the point-group as follows:

$$\mathcal{A}_6 = 1,\ ap_{60°},\ a_{120°},\ c,\ a_{240°},\ ap_{300°}.$$

Using the same symbols, we may write:

$$\mathfrak{A}_3 = 1,\ ap_{300°},\ a_{240°},\ c,\ a_{120°},\ ap_{60°}.$$

[6] FRIEDRICH BECKE. *Inversionsachse und Spiegelachse.* N. Jahrb. f. Min., B. B., 57A: 173–202. 1927. In the preparation of this article, I had overlooked Becke's important paper, which was brought to my attention by Dr. A. F. ROGERS.

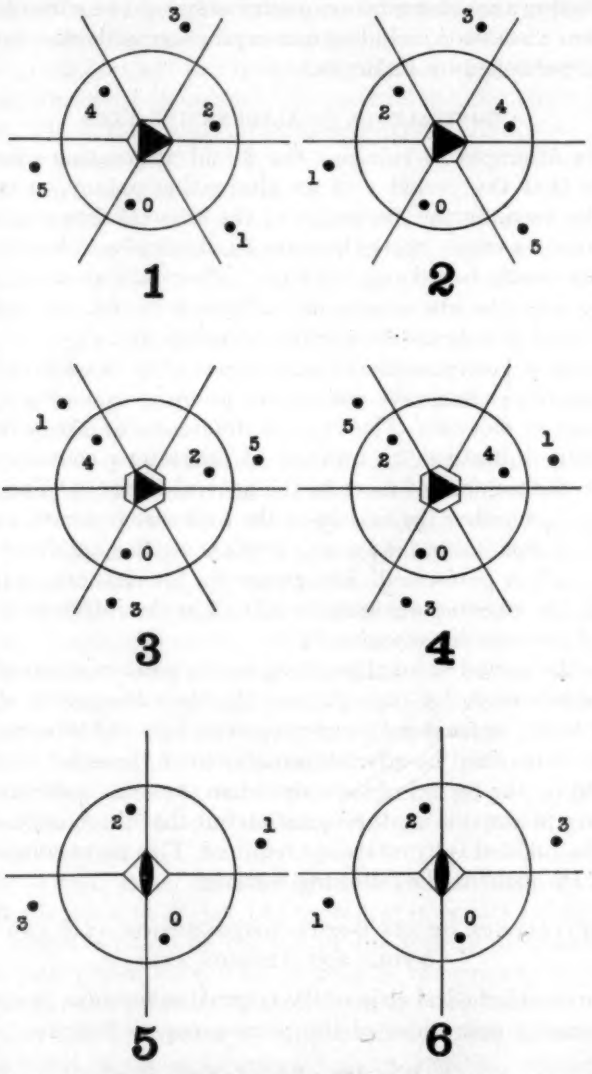


Fig. 1. General form in the point-group $\mathcal{P}_6$ (counter-clockwise rotations)
Fig. 2. General form in the point-group $\mathcal{C}_{A_3}$ (counter-clockwise rotations)
Fig. 3. General form in the point-group $\mathcal{C}_{A_6}$ (counter-clockwise rotations)
Fig. 4. General form in the point-group $\mathcal{P}_3$ (counter-clockwise rotations)
Fig. 5. General form in the point-group $\mathcal{P}_4$ (counter-clockwise rotations)
Fig. 6. General form in the point-group $\mathcal{C}_{A_4}$ (counter-clockwise rotations)

This will become apparent from inspection of the stereographic projection[7] of the general form obtained in each case (Figs. 1 and 2). The rotations are taken counter-clockwise. The six equivalent faces are numbered from 0 to 5, thus indicating the power of the generating operation which is $ap_{60°}$ in the case of $\mathcal{P}_6$ and $ca_{120°}$ in the case of $\mathcal{C}_3$.

The equivalence of the operations in both cases may be shown as follows. Let $x$ represent the 120° rotoversion $ca_{120°}$. The powers of that operation will be:

$$x^0 = 1,$$
$$x = ca_{120°} = ap_{300°},$$
$$x^2 = a_{240°},$$
$$x^3 = c,$$
$$x^4 = a_{120°},$$
$$x^5 = ca_{240°} = ap_{60°}.$$

The two groups $\mathcal{P}_6$ and $\mathcal{C}_3$ are thus identical since both contain the same operations. The only difference lies in the sequence of the symmetry operations, but it is well known that the elements of a group may be listed in any order (or rearranged).

Another way of illustrating the identity of the two groups is to remark that the six equivalent faces of Fig. 1 can be derived by means of a $\mathcal{C}_3$ and those of Fig. 2 by means of an $\mathcal{P}_6$ provided simply that the convention of signs be reversed (clockwise instead of counter-clockwise rotations).

## EQUIVALENCE OF THE 6-FOLD ROTOVERSION AXIS AND THE 3-FOLD ROTOFLECTION AXIS

For the trigonal dipyramidal class of the hexagonal system, the identity of the two groups $\mathcal{C}_6$ and $\mathcal{P}_3$ can be proved in like manner. The 1st power of $ap_{120°}$ is equal to the 5th power of $ca_{60°}$; the 2nd of $ap_{120°}$ to the 4th of $ca_{60°}$, etc.

The six operations may be written indifferently:

$$\mathcal{C}_6 = 1, ca_{60°}, a_{120°}, p, a_{240°}, ca_{300°},$$

or

$$\mathcal{P}_3 = 1, ca_{300°}, a_{240°}, p, a_{120°}, ca_{60°}.$$

The general form is shown in stereographic projection (Figs. 3 and 4).

[7] The face-poles are projected on the equatorial plane; the projecting point is the South pole for all faces.

The same remark holds true with regard to the order in which the six faces are derived and the convention of sign for the rotations.

## EQUIVALENCE OF THE 4-FOLD ROTOFLECTION AND ROTOVERSION AXES

For the sake of completeness and in order to stress the perfect analogy of the three cases, the identity of $\mathcal{P}_4$ and $\mathcal{C}_4$ (tetragonal disphenoidal class of the tetragonal system) is also shown here by means of the usual projections (Figs. 5 and 6).

The two groups may be written:

$$\mathcal{P}_4 = 1, ap_{90°}, a_{180°}, ap_{270°},$$

and

$$\mathcal{C}_4 = 1, ap_{270°}, a_{180°}, ap_{90°}.$$

Here again, the second group contains the rearranged elements of the first group. The equivalence of the 4-fold alternating axes was brought out by A. F. Rogers in his article.

It has been shown that an alternating axis of period 3 can be used to represent a point-group of order 6. This result leaves intact the method proposed by Rogers for the derivation of faces in the general form. Whether rotoflection alone or rotoversion alone be used, it is possible to derive each and every face of the general form $\{hkl\}$ directly from any arbitrarily selected face.

The symmetry operations of the rhombohedral class (trigonal subsystem), the tetragonal disphenoidal class (tetragonal system), and the trigonal dipyramidal class (hexagonal system) may be listed in either one of the two following ways:

$$\begin{aligned} \mathcal{C}_3 &= 1, ca_{120°}, a_{240°}, c, a_{120°}, ca_{240°}, \\ \mathcal{C}_4 &= 1, ca_{90°}, a_{180°}, ca_{270°}, \\ \mathcal{C}_6 &= 1, ca_{60°}, a_{120°}, p, a_{240°}, ca_{300°}; \end{aligned} \tag{I}$$

or

$$\begin{aligned} \mathcal{P}_6 &= 1, ap_{60°}, a_{120°}, c, a_{240°}, ap_{300°}, \\ \mathcal{P}_4 &= 1, ap_{90°}, a_{180°}, ap_{270°}, \\ \mathcal{P}_3 &= 1, ap_{120°}, a_{240°}, p, a_{120°}, ap_{240°}. \end{aligned} \tag{II}$$

The equivalence of the new symbols with those employed by A. F. Rogers is given below:

$$\begin{aligned} ca_{120°} &= ap_{300°}, \quad ca_{240°} = ap_{60°}, \\ ca_{90°} &= ap_{270°}, \quad ca_{270°} = ap_{90°}, \\ ap_{120°} &= ca_{300°}, \quad ap_{240°} = ca_{60°}. \end{aligned}$$

### CHOICE OF THE ALTERNATING AXES

There are two main possibilities: (1) Discard the 3-fold alternating axes and use $\mathcal{A}_4$ (or $\mathcal{C}A_4$), $\mathcal{A}_6$, and $\mathcal{C}A_6$. This is the course followed by Rogers. (2) Use one kind of alternating axes only, either rotoflection axes ($\mathcal{A}_6$, $\mathcal{A}_4$, $\mathcal{A}_2$) or rotoversion axes ($\mathcal{C}A_2$, $\mathcal{C}A_4$, $\mathcal{C}A_6$). The exclusive use of rotoversion axes was the solution adopted by international agreement at the Zürich meeting.

The merits of the alternating axes of even period will be discussed first.

The advantage of this solution can be seen by glancing over the list of the symmetry symbols given by Rogers for the 32 crystal classes[8]: the order of the point-group (hence, the number of faces in the general form) can be read directly from the symmetry symbol or can be deduced from it by a simple count:

(a) When there is only one element of symmetry present, its order is the order of the group. It is equal to 2 in the case of a plane of symmetry (P), a center (C), or a 2-fold axis of symmetry ($A_2$). In general, the subscript of the axis symbol gives its order ($A_2$, $A_3$, $A_4$, $\mathcal{A}_4$, $\mathcal{A}_6$, $\mathcal{C}A_6$).

(b) When there are several symmetry elements, the order of the group is given by 1 (identical operation) plus the order of each element each decreased by one. *Example:*

$$3A_4.4A_3.6A_2, \text{ order} = 1+3\times3+2\times4+1\times6 = 24.$$

Symmetry elements placed between parentheses in Rogers' symbols must be ignored in the count since they are implicitly included in the other symmetry elements listed.

(c) When two (or more) symmetry elements have operations in common, brackets are used. The total obtained by the above rule should be decreased accordingly. Minus one for one element between brackets.

*Example:*

$$A_4[\mathcal{A}_4].P.C, \text{ order} = 1+3\times2+1\times2-1 = 8.$$

Minus four for two elements between brackets.

*Example:*

$$A_6[\mathcal{A}_6][\mathcal{C}A_6](P).(C), \text{ order} = 1+5\times3-4 = 12.$$

(d) In two isometric classes (diploidal and hexoctahedral) where 4 $\mathcal{A}_6$ are found, it should also be realized that the center is included

[8] Op. cit., p. 200.

in each one of these, so that the order found must be corrected accordingly (minus 3).

*Example:*

$$4\ A_6.3A_2.3P.(C),\ \text{order} = 1+5\times4+3+3-3=24.$$

The value of using one kind of alternating axes is of course simplicity; it is better to resort to one type of alternating symmetry than to two.

There is no particular advantage in choosing rotoflection only. The selection of rotoversion axes, on the contrary, lends itself to a better division of the 32 classes into systems. This fact, which had been pointed out by Hilton,[9] probably accounts for the adoption of rotoversion axes by the Zürich convention.

Let us observe that the rhombohedral and hexagonal scalenohedral classes, both of which belong to the trigonal subsystem, have a $\alpha_3$ in their respective symmetry symbols. Similarly, the trigonal dipyramidal and ditrigonal dipyramidal classes of the hexagonal system include the symmetry element $\alpha_6$. A further advantage is seen in the isometric system where all five classes now have four 3-fold axes (either rotation axes or rotoversion axes) parallel to the cube diagonals.

It will be realized that the reasons for selecting rotoversion axes are of no fundamental importance, the object being merely to attain a set of convenient symbols fitting in the frame of the traditional classification into systems. It must be added that this aim, modest as it was, has been fully reached.

## THE INTERNATIONAL SYMMETRY SYMBOLS

The international system of symmetry notation agreed upon at the Zürich meeting, August 28–31, 1930, is due to the collaboration of C. Hermann, Ch. Mauguin, J. D. Bernal, P. P. Ewald, and others. It may be said to be epoch making in that, through its comprehensiveness, it bridges the gap which so far has divided geometrical and structural crystallographers. It remarkably brings out the relationships between the various groups of symmetry operations in the 3-dimensional space: the 32 point-groups or groups without any translation (one point remaining fixed), the 75 chain-groups or groups with one independent translation only, the 80 net-groups or groups

[9] HAROLD HILTON. *Note on the thirty-two classes of symmetry.* Min. Mag., **14**: 261–3. 1906.

with two translations, and the 230 space-groups or groups with three translations.

The 230 space-groups and the 32 point-groups obviously are the most important from the practical viewpoint. The new symbols recognize the fact that each one of the 230 space-groups is isomorphous with one of the 32 point-groups: slight modification of a space-group symbol immediately leads to the symbol of the isomorphous point-group.

It appears that, from now on, the Zürich symbols will be used both in geometrical and in structural crystallography. It seems advisable

TABLE 1.—PRINCIPLE OF THE INTERNATIONAL SYMMETRY SYMBOLS

| Elements of Symmetry: | Symbols: |
|---|---|
| Rotation axes | 1, 2, 3, 4, 6. |
| *Remark:* Any straight line may be considered a 1-fold rotation axis. Class 1 is the pedial class. | |
| Rotoversion axes: | |
| With an odd period | $\bar{1}$, $\bar{3}$. |
| *Remark:* These always contain the center of symmetry; the axis is at the same time a rotation and a rotoversion axis of the same period. Class $\bar{1}$ is the pinakoidal class. | |
| With an even period: | |
| Devoid of center of symmetry | $\bar{2}$, $\bar{4}$, $\bar{6}$. |
| *Remarks:* (a) a $2\bar{n}$-fold rotoversion axis is at the same time a $n$-fold rotation axis. | |
| (b) $\bar{2}$ is a plane of symmetry $m$ | $\bar{2}=m$. |
| (c) $\bar{4}$ is irreducible | $\bar{4}$. |
| (d) $\bar{6}$ includes a 3-fold rotation axis and a plane of symmetry perpendicular to it | $\bar{6}=3/m$. |
| Centro-symmetric | $2/m$, $4/m$, $6/m$. |
| *Remark:* These axes are at the same time rotation and rotoversion axes of the same period; they always include a plane of symmetry normal to the axis. | |

to introduce their use in elementary courses in crystallography. The present discussion of alternating axes may serve as an introduction to the study of the new symbols the simplicity of which is mostly due to the use of the sole rotoversion axes.

A brief summary of the notation will be given here insofar as it deals with the 32 crystal classes (see Table I). The new symmetry symbols are listed in Table II. Other symbols are also given for comparison: Schoenflies, A. F. Rogers, together with the nomenclatures of Groth and Dana.

In the *complete* form of the Mauguin point-group symbols, there are as many terms as there are kinds of symmetry axes in the group. In an orthorhombic symmetry symbol, the three terms refer to the *a*-axis, the *b*-axis, and the *c*-axis respectively (right-handed system

TABLE 2.—COMPARISON OF VARIOUS SYSTEMS OF POINT-GROUP SYMMETRY SYMBOLS

| Systems | Schoenflies | Mauguin (International) Complete | Mauguin (International) Abridged | Mauguin (International) Preferred | A. F. Rogers | Dana | Groth (modified) |
|---|---|---|---|---|---|---|---|
| Triclinic | $C_1$ | $1$ | $1$ | $1$ | | Asymmetric | Pedial |
| | $S_2$ | $\bar{1}$ | $\bar{1}$ | $\bar{1}$ | $C$ | Normal | Pinakoidal |
| Monoclinic | $C_1^h$ | $m$ | $m$ | $m$ | $P$ | Clinohedral | Domatic |
| | $C_2$ | $2$ | $2$ | $2$ | $A_2$ | Hemimorphic | Sphenoidal |
| | $C_2^h$ | $2/m$ | $2/m$ | $2/m$ | $A_2.\ P.\ C$ | Normal | Prismatic |
| Orthorhombic | $C_{2v}$ | $2\ m\ m$ | $2\ m$ | $m\ m$ | $A_2.\ 2P$ | Hemimorphic | Rhombic pyramidal |
| | $V$ | $2\ 2\ 2$ | $2\ 2$ | $2\ 2\ 2$ | $3A_2$ | Sphenoidal | Rhombic disphenoidal |
| | $V^h$ | $2/m\ 2/m\ 2/m$ | $2/m\ m$ | $m\ m\ m$ | $3A_2.\ 3P.\ C$ | Normal | Rhombic dipyramidal |
| Tetragonal | $S_4$ | $\bar{4}$ | $\bar{4}$ | $\bar{4}$ | $\mathcal{A}P_4$ | Tetartohedral | Tetragonal disphenoidal |
| | $V_d$ | $\bar{4}\ 2\ m$ | $\bar{4}\ 2$ | $\bar{4}\ 2\ [m$ | $\mathcal{A}P_4.\ 2A_2.\ 2P$ | Sphenoidal | Tetragonal scalenohedral |
| | $C_4$ | $4$ | $4$ | $4$ | $A_4$ | Pyramidal hemimorphic | Tetragonal pyramidal |
| | $C_4^h$ | $4/m$ | $4/m$ | $4/m$ | $A_4[\mathcal{A}P_4].\ P.\ C$ | Tripyramidal | Tetragonal dipyramidal |
| | $C_4^v$ | $4\ m\ m$ | $4\ m$ | $4\ m\ m$ | $A_4.\ 4P$ | Hemimorphic | Ditetragonal pyramidal |
| | $D_4$ | $4\ 2\ 2$ | $4\ 2$ | $4\ 2$ | $A_4.\ 4A_2$ | Trapezohedral | Tetragonal trapezohedral |
| | $D_4^h$ | $4/m\ 2/m\ 2/m$ | $4/m\ m$ | $4/m\ m\ m$ | $A_4[\mathcal{A}P_4].\ 4A_2.\ 5P.\ C$ | Normal | Ditetragonal dipyramidal |
| Trigonal | $C_3$ | $3$ | $3$ | $3$ | $A_3$ | Trigonal tetartohedral hemimorphic | Trigonal pyramidal |
| | $C_3^i$ | $\bar{3}$ | $\bar{3}$ | $\bar{3}$ | $\mathcal{A}P_6.\ (C)$ | Trirhombohedral | Rhombohedral |
| | $C_3^v$ | $3\ m$ | $3\ m$ | $3\ m$ | $A_3.\ 3P$ | Rhombohedral hemimorphic | Ditrigonal pyramidal |
| | $D_3$ | $3\ 2$ | $3\ 2$ | $3\ 2$ | $A_3.\ 3A_2$ | Trapezohedral | Trigonal trapezohedral |
| | $D_3^d$ | $3\ 2/m$ | $3\ m$ | $3\ m$ | $\mathcal{A}P_6.\ 3A_2.\ 3P.\ (C)$ | Rhombohedral | Hexagonal scalenohedral |
| Hexagonal | $C_3^h$ | $\bar{6}$ | $\bar{6}$ | $\bar{6}$ | $CA_6(P)$ | Trigonal tetartohedral | Trigonal dipyramidal |
| | $D_3^h$ | $\bar{6}\ 2\ m$ | $\bar{6}\ 2$ | $\bar{6}\ 2\ m$ | $CA_6(P).\ 3A_2.\ 3P$ | Trigonal | Ditrigonal dipyramidal |
| | $C_6$ | $6$ | $6$ | $6$ | $A_6$ | Pyramidal hemimorphic | Hexagonal pyramidal |
| | $C_6^h$ | $6/m$ | $6/m$ | $6/m$ | $A_6[\mathcal{A}P_6][CA_6](P).\ (C)$ | Tripyramidal | Hexagonal dipyramidal |
| | $C_6^v$ | $6\ m\ m$ | $6\ m$ | $6\ m\ m$ | $A_6.\ 6P$ | Hemimorphic | Dihexagonal pyramidal |
| | $D_6$ | $6\ 2\ 2$ | $6\ 2$ | $6\ 2$ | $A_6.\ 6A_2$ | Trapezohedral | Hexagonal trapezohedral |
| | $D_6^h$ | $6/m\ 6/m\ 6/m$ | $6/m\ m$ | $6/m\ m\ m$ | $A_6[\mathcal{A}P_6][CA_6](P).\ 6A_2.\ 6P.\ (C)$ | Normal | Dihexagonal dipyramidal |
| Isometric | $T$ | $2\ 3$ | $2\ 3$ | $2\ 3$ | $4A_3.\ 3A_2$ | Tetartohedral | Tetartoidal |
| | $T^h$ | $2/m\ 3$ | $2/m\ 3$ | $m\ 3$ | $4\mathcal{A}P_6.\ 3A_2.\ 3P.\ (C)$ | Pyritohedral | Diploidal |
| | $T^d$ | $\bar{4}\ 3\ m$ | $\bar{4}\ 3$ | $\bar{4}\ 3\ m$ | $3\mathcal{A}P_4.\ 4A_3.\ 6P$ | Tetrahedral | Hextetrahedral |
| | $O$ | $4\ 3\ 2$ | $4\ 3$ | $4\ 3$ | $3A_4.\ 4A_3.\ 6A_2$ | Plagiohedral | Gyroidal |
| | $O^h$ | $4/m\ 3\ 2/m$ | $4/m\ 3$ | $m\ 3\ m$ | $3A_4[3\mathcal{A}P_4].\ 4\mathcal{A}P_6.\ 6A_2.\ 9P.\ (C)$ | Normal | Hexoctahedral |

used by crystallographers). In the dimetric systems (trigonal, tetragonal, hexagonal), the first term refers to the vertical axis (*c*-axis), the last (one or two) to the horizontal axes of two-fold symmetry. In the isometric system, the first term refers to the axes parallel to the edges of the cube; the second term, to the axes parallel to the body-diagonals of the cube; the third term, to the axes parallel to the face-diagonals of the cube. All isometric point-group symbols have the figure 3 as their second term.

*Abridged symbols* are obtained by omitting the third term in all cases and writing $m$ instead of $2/m$ for the second term of the symbol in the case of a centro-symmetric point-group.

The *preferred symbols* retain *all symmetry planes* in view of generalizations to be made in the space-group symmetry symbols (see Mauguin, *loc. cit.*).

It will be noticed that the Greek letter $\mu$ of the former Hermann's symbols is now replaced by $m$, the initial of mirror, to designate the plane of symmetry.

The new international notation aims at representing the groups by short, self-explanatory symbols listing a minimum of symmetry elements, sufficient to characterize all the symmetry present.

## THE STATUS OF THE CENTER OF SYMMETRY

In connection with the preceding discussion of alternating axes, it is thought appropriate to consider briefly the so-called validity of the center as a true element of symmetry.

First of all, it should be realized that there is no point of fundamental importance to be settled in this "problem" and that all discussions on the subject, due to the very nature of the case, are apt to be vain and sterile. The following remarks can be made.

There is no more reason to discard the center of symmetry and replace it by a 2-fold rotoflection axis than there is to abolish the plane of symmetry and substitute a 2-fold rotoversion axis for it.

In the first instance, the bare fact is this: in a centro-symmetric crystal, to any face arbitrarily selected at one end of the crystal, there corresponds a parallel face, similar (equivalent) to the first, at the opposite end of the crystal. It is possible to derive the second face from the first by means of a symmetry operation. Whether this operation should be characterized as an inversion through the center or a 180° rotoflection about a rotoflection axis (which cannot be defined in direction) is only a question of words; the fundamental observation will not be changed by either interpretation.

Likewise, in the case of a plane of symmetry, the fact is that to every face on one side of a plane there corresponds a similar face, the *mirror-image* of the first, on the other side of the plane. Why should one consider the operation involved as a 180° rotoversion about a rotoversion axis (normal to the plane of symmetry) when this new picture has no advantage over the age-old and simple concept of the "reflection"? The only essential point to be stressed is the existence of a symmetry operation by means of which a face and its mirror-image can be derived from each other. It must be admitted that there is no need to introduce a composite operation when there is already a simple operation providing for direct derivation.

The status of the center of symmetry and that of the plane of symmetry are thus intimately linked. The use of the composite operation in either case masks the facts more than it brings them out. Both center and plane of symmetry should therefore be retained.

ACKNOWLEDGMENTS

I wish to thank my former professor Dr. Austin F. Rogers of Stanford University for a critical reading of this manuscript and for his continued interest in my work. Valuable suggestions were also obtained from Dr. George Tunell of the Geophysical Laboratory, which are gratefully acknowledged.

## BOTANY.—*The genus* Chionopappus *of Bentham* (*Asteraceae*).[1]

S. F. BLAKE, Bureau of Plant Industry.

In 1873 George Bentham described the new genus *Chionopappus* of the tribe "Mutisiaceae," subtribe Onosorideae, in the family Compositae. It was based on a single species, to which no name was assigned, which was said to be a native of northern Peru. Nothing has been added to our knowledge of the genus, and after the lapse of more than sixty years it remains a "genus without a species." Baillon (1882) placed it in the Mutisieae, and Hoffmann (1893) in the Mutisieae-Gochnatinae, both accounts being based entirely on Bentham's original description. Bentham remarked that the genus was remarkable in its tribe for its opposite leaves and paleaceous receptacle, and abnormal in its ligulate not bilabiate ray corollas, but that in its style and its rays, 4-merous according to their venation, it agreed with no other tribe.

[1] Received July 18, 1935.

During the last twenty years there have come to hand from the Department of Lima, Peru, several collections of a Liabum-like Composite agreeing closely with Bentham's description in all major features—foliage, heads, involucre, paleaceous as well as pilose receptacle, corollas, and pappus—but differing in at least two points of structure that are of great importance in the classification of Compositae. Bentham described the style of the hermaphrodite flowers as undivided or barely emarginately 2-lobed, and the anthers as sagittate at base and with long, very slenderly caudate-acuminate auricles. In the recently collected plants the style branches are rather long, linear, obtusish, and hispidulous outside with the hairs continuing far below the fork, almost in the manner of *Vernonia*, and the anthers, while deeply sagittate, are polliniferous almost to the tip of the lance-linear auricles, with only a very short (about 0.1–0.2 mm. long) obtuse cellular sterile apiculation, and so not truly caudate. Through the kindness of Sir Arthur W. Hill, I have been permitted to borrow Bentham's type sheet[2] from the Kew Herbarium and resolve the riddle.

The type sheet bears three pieces of stem a few inches long and a pocket containing flowers, achenes, pappus, and a few phyllaries derived from one of the heads, as well as a head in bud. The specimens are nearly leafless, bearing altogether only a couple of pairs of upper leaves and a few bracts. They are accompanied by a printed label: "Lima et Peruvia septentrionalis. H. Cuming, 1831," with the written number 996. In publishing the genus, Bentham quoted only the second part of the habitat as given, whereas recent collections are all from the region of Lima, indicating that Cuming's plant probably came from the same region, in central western Peru. The name *Chionopappus* does not appear on the sheet. In addition to some notations by Bentham on the details of structure, the sheet bears the name "*Liabum*? n. sp." and "Cf. Erato"[3] in Bentham's hand. The specimens are clearly identical specifically with the later collections by Rose, Macbride, and Pennell. Examination shows that most if not all the detached styles preserved in the pocket have had their tips chewed off by insects, thus presenting the appearance of being undivided recorded by Bentham. Examination of one of the heads on the sheet with a lens, however, reveals uninjured forked styles

[2] The sheet sent me is one from Bentham's own herbarium. Mr. John S. L. Gilmore writes that there is another sheet of the same collection, also with very scanty material, in the Hooker Herbarium.

[3] *Erato* is now treated as a section of *Liabum*.

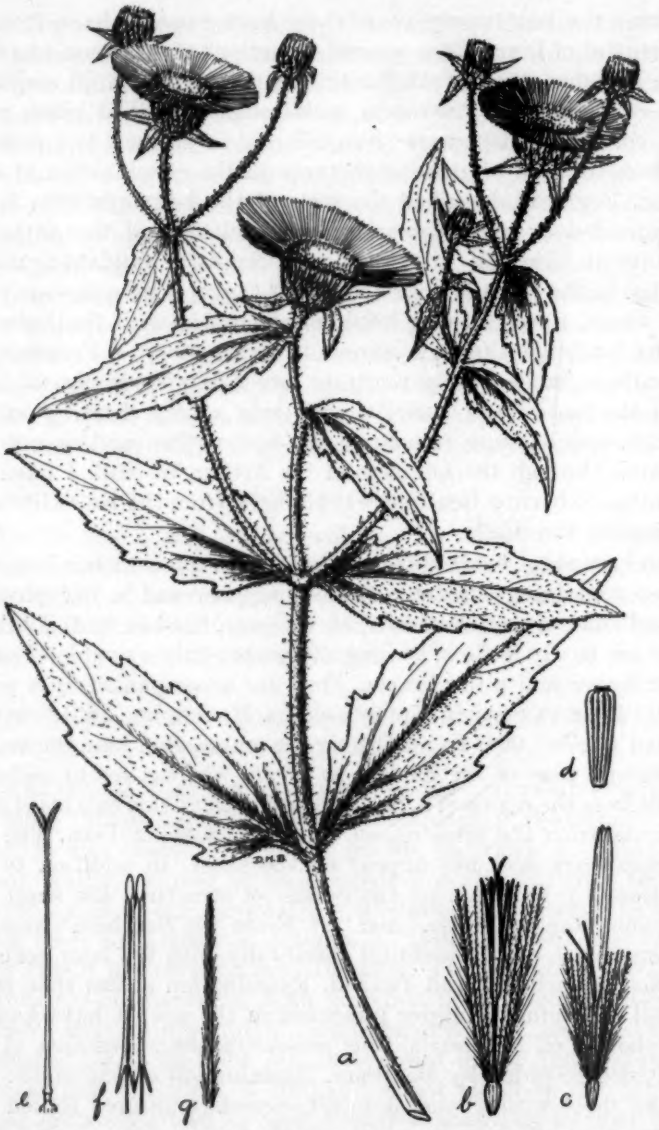


Fig. 1.—*Chionopappus benthamii* Blake.—*a*, plant, ×1; *b*, disk flower, ×3½; *c*, ray flower, ×2½; *d*, achene with pappus fallen, ×8; *e*, style of disk flower, ×4½; *f*, two stamens, ×10; *g*, receptacular pale, ×4.—All drawn from *Macbride & Featherstone* 162, in the Field Museum, except fig. *d*, which is drawn from the type, *Cuming* 996, in the Kew Herbarium.

protruding from some of the anther-tubes. The anthers are somewhat shriveled and appear to have more slender auricles than the recent specimens, but are not really different in structure. In no case do they have the stiff texture so characteristic of the terminal appendages and the anther tails in both Mutisieae and Cynareae. Bentham's description of the heads as nodding was obviously based on only one of the four heads on the type sheet, and since the numerous heads on the recent specimens are all erect, the appearance of this head must be attributed to some peculiarity of preparation. Finally, Bentham's emphasis on the 4-merous nature of the ray corollas, as deduced from their venation—the nerves were described as 4—as an indication that the genus could go in no other tribe is a curious slip, for the reason that the alternation of nerves and teeth which is fundamental in the corollas of Compositae makes it necessary for a normal 3-merous ray to have four nerves[4] (when supplementary ones are not present), and for a 4-merous ray to have five.

Since the principal characters relied on by Bentham to place the genus in the Mutisieae are based on wrong interpretation of the material, there arises a question as to its proper position. Its combination of characters rules out all tribes except the Senecioneae (subtribe Liabinae), and—doubtfully, from the fact that the anthers are not truly caudate—the Inuleae (subtribe Buphthalminae) and the Mutisieae (subtribe Gochnatinae of Hoffmann). Comparison with these groups shows that the natural position of *Chionopappus* is definitely in the subtribe Liabinae next to *Liabum*, from which genus, taken in its broad sense, it differs primarily only in its truly paleaceous receptacle[5] and its 1-seriate pappus of relatively few long-plumose awns united at base and deciduous in a ring. In all other features—habit, opposite leaves which are tomentose beneath, involucre, several-seriate narrow rays, disk corollas, achenes, styles, and anthers—it can be closely matched in the *Liabum* group. The revised generic description and the specific description follow.

[4] One running toward each sinus, one on each side of lamina about midway between the sinus-nerve and the margin.

[5] Bentham and Hooker described the receptacle in *Liabum* as naked, alveolate, or fimbrillate. Rydberg (N. Am. Fl. 34: 289. 1927), who splits the North American and West Indian representatives of *Liabum* into 5 genera, describes it in his restricted genus *Liabum* (including the *L. umbellatum* and *L. igniarium* groups) as "bristly-fimbriate to chaffy with subulate paleae." The receptacle in these species does not bear true paleae but is deeply alveolate, with the margins of the alveolae prolonged into stiff mostly subulate awn-like structures about the length of the achenes and surrounding them. *Chionopappus*, in contrast, has true paleae in the shape of slender linear-subulate chaff, one to each flower. That this difference is not sufficient to exclude *Chionopappus* from the *Liabum* alliance is indicated by a more or less similar variation in several of the tribes of Compositae.

CHIONOPAPPUS Benth. in Benth. & Hook. Gen. Pl. 2: 485. 1873 (without species name)

Suffrutescent, branching, pubescent; leaves opposite, ovate to oblong-ovate, short-petioled, triplinerved, coarsely serrate, green and scabrous-pubescent above, white-tomentose beneath; heads medium-sized, heterogamous, radiate, short-peduncled, mostly ternate at tips of stem and branches, the rays yellow, the disk purple; involucre campanulate or hemispheric-campanulate, usually with a few leafy bracts at base, the proper phyllaries strongly graduate, about 5–7-seriate, ovate to (inner) lance-linear, acuminate, erect, subchartaceous, the outer with short and narrow obscurely herbaceous tip; receptacle broad, flat, densely long-pilose, paleaceous throughout with linear-subulate firm pales about equaling the pappus; rays very numerous, 2–3-seriate, pistillate, fertile, yellow, the lamina spreading, linear, usually 3-denticulate, 4-nerved; disk flowers very numerous, hermaphrodite, fertile, their corollas regular, tubular, slender-funnelform, deeply 5-fid, the lobes much longer than the throat; anthers deeply sagittate at base, with obscurely appendaged auricles, and with oblong-ovate apical appendages; style hispid far below the fork, the branches linear, obtuse, at length spreading, hispidulous outside, stigmatiferous over whole inner surface, unappendaged; achenes oblong or narrowly obovoid, somewhat compressed, 8–10-ribbed, small, glabrous; pappus of 10–15 1-seriate very slender long-plumose white awns, united at base and deciduous in a ring. Type species, *Chionopappus benthamii*.

**Chionopappus benthamii** Blake, sp. nov.

Suffrutescens ca. 1 m. altus opposite ramosus; caulis subteres fragilis albidus v. brunneus subdense hirsuto-pilosus pilis patentibus multiloculatis basi subtuberculatis et parum puberulus, aetate glabratus; internodia 2.5–6 cm. longa; petioli 1–2 mm. longi vix marginati basi connati, basibus demum incrassatis et breviter vaginiformibus; laminae ovatae v. oblongo-ovatae 3.8–6 cm. longae 1.5–2.8 cm. latae acutae calloso-mucronulatae basi cuneatae v. rotundato-cuneatae in petiolum breviter decurrentes prope basin triplinerviae subtenues grosse et irregulariter serratae dentibus majoribus ca. 6–8-jugis calloso-mucronulatis supra virides dense scabro-hispidae et hispidulae pilorum basibus tuberculatis persistentibus aetate rugoso-bullatae subtus venis majoribus breviter hirsutis exceptis dense et persistenter alboarachnoideo-tomentosae; capitula apice caulis et ramorum saepe ternata erecta ca. 2–3.3 cm. lata basi bracteis 2–4 foliis similibus sed multo minoribus lanceolatis patentibus v. reflexis suffulta, pedunculis sicut caule pubescentibus 0.7–4 cm. longis; discus (siccitate) 1–1.2 cm. altus 1–2 cm. diam.; involucri 9–11 mm. alti juventate paullum arachnoideo-tomentosi phyllaria flavido-albida ad apicem saepe purpurascentia inconspicue 1–3-nervia dense sordido-puberula et versus apicem saepius patenti-hirsuta, exteriora acuminata apice interdum sublaxa breviter subherbacea, interiora linearia v. linearilanceolata longe acuminata exterioribus multo angustiora; radii ca. 100 aurei apice interdum purpurascentes ad apicem tubi et basin laminae sparse puberuli ceterum glabri, tubo 5 mm. longo, lamina ca. 11 mm. longa 1 mm. lata; corollae disci valde numerosae glabrae infra pallidae supra medium saturate purpureae ca. 8mm. longae (tubo ca. 3.5 mm., faucibus 1.5–1.8 mm., dentibus anguste triangularibus acuminatis apice intus paullum incrassatis 2.5–

3 mm. longis); paleae receptaculi anguste lineari-subulatae firmae albidae longe ciliatae et pilosae ca. 8 mm. longae; achenia albida 2 mm. longa 0.5 mm. lata; pappus niveus 7–8 mm. longus, aristis angustissimis complanatis ad apicem multo brevius plumosis.

PERU: "Lima et Peruvia septentrionalis," 1831, *Cuming* 996 (type, Herb. Kew; photog., U. S. Nat. Herb.); vicinity of Matucana, 9 July 1914, *Dr. & Mrs. J. N. Rose* 18663 (U. S. Nat. Herb.); rock crevices and in loose rock, Matucana, 12 April–3 May 1922, *Macbride & Featherstone* 162 (Field Mus., U. S. Nat. Herb.); open rocky slopes, along Rio Chillón, near Viscas, Dept. Lima, alt. 1800–2000 m., 10–15 June 1925, *Pennell* 14480 (U. S. Nat. Herb.).

Macbride and Featherstone describe their plant as woody at base, very brittle, 3 ft. high; Pennell describes his as a shrub, with "light cadmium" rays and "bordeaux" disk.

PALEOBOTANY.—*An occurrence of the genus* Cladoxylon *Unger, in North America.*[1] CHARLES B. READ, U. S. Geological Survey. (Communicated by ROLAND W. BROWN.)

In 1882 J. W. Dawson published a brief account of a specimen of *Cladoxylon mirabile* Unger from the Styliola limestone (Genundewa limestone member of Genesee shale) of western New York.[2] Although no figures are given, it is clear from the text that the plant was of the *Cladoxylon* type and distinct from *Asteropteris noveboracensis*, with which Dawson was well acquainted. It is unfortunate that in most of the more recent accounts of *Cladoxylon* this single American record had been overlooked or else considered too questionable to mention.

In the collection of thin sections of fossil plants prepared under the direction of the late Dr. F. H. Knowlton and now in the hands of the U. S. Geological Survey there is a single transverse section labeled *Cladoxylon mirabile* Unger and recorded from the "Genesee shale, Styliola layer (Genundewa limestone), Canandaigua, New York," and presented to Knowlton by John M. Clarke. Since Clarke was the collector of Dawson's material, it is probable that this section is from the block recorded in the Canadian report. At any rate the specimen is material evidence of the occurrence of *Cladoxylon* in America and therefore deserves to be brought to the attention of paleobotanists. The writer prefers to record this form as new rather than to place it in a doubtful synonomy with the poorly figured *C. mirabile* or other European species.

[1] Published with the permission of the Director of the U. S. Geological Survey. Received July 8, 1935.

[2] DAWSON, J. W. *The fossil plants of the Erian (Devonian) and Upper Silurian formations of Canada.* Canada Geol. Survey Pt. 2: 126. 1882.

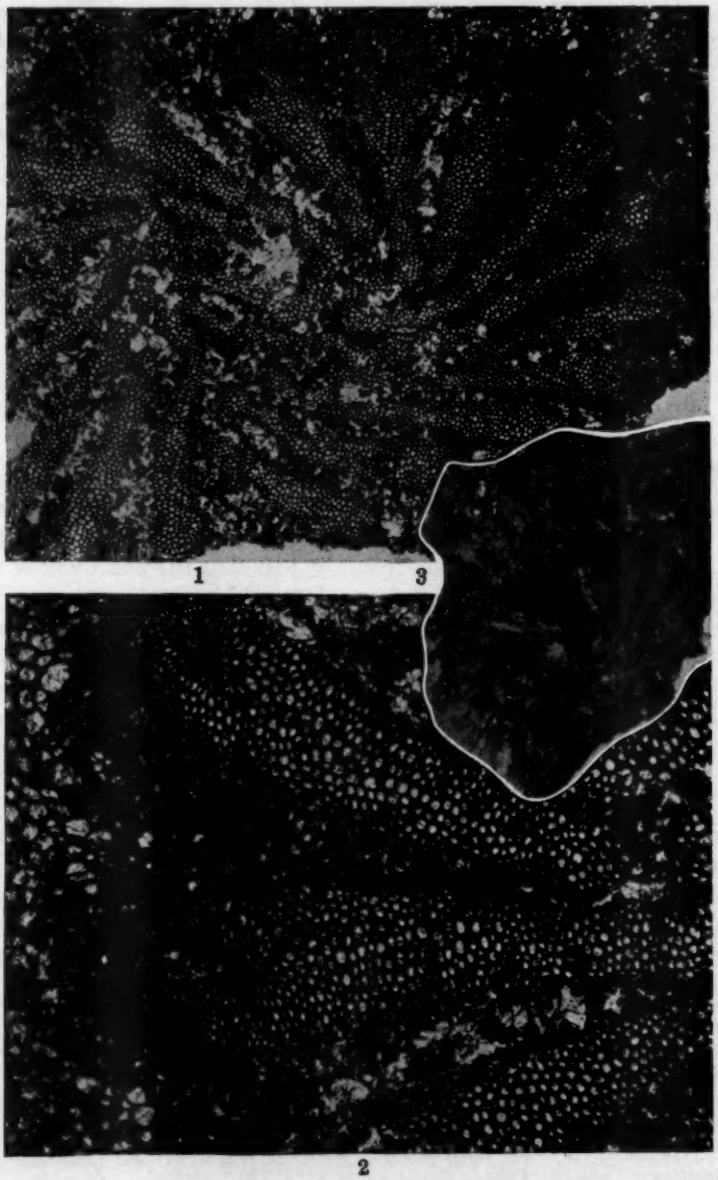


Fig. 1.—Photograph of transverse section of *Cladoxylon dawsoni*, n. sp., showing the radiating bands of xylem. ×18. Fig. 2.—Same specimen showing the details of two of the plates of xylem. Note the "loops" near the outer edge indicating the position of protoxylem. ×42. Fig. 3.—Thin section of *C. dawsoni*, n. sp., showing the general aspect of the plant. ×6½.

## CLADOXYLON Unger

Unger, Franz, in Richter, Reinhard, and Unger, Franz. *Beitrag zur Paläontologie des Thüringer Waldes.* K. Akad. Wiss. Wien, Math.-nat. Klasse, Denkschr. Bd. 11: 179. 1856.

Solms-Laubach, H. Graf zu. *Ueber die seinerzeit von Unger beschriebenen strukturbietenden Pflanzenreste des Unterculm von Saalfeld in Thüringen.* K. preuss. geol. Landesanstalt, pp. 52–56. 1896.

### Cladoxylon dawsoni, n. sp.

*Cladoxylon mirabile* Unger. Dawson, J. W. *The fossil plants of the Erian (Devonian) and Upper Silurian formations of Canada.* Canada Geol. Survey. Pt. 2: 126. 1882.

A photograph at low magnification of the thin section of *Cladoxylon dawsoni* from New York is shown in Figure 3. It is clear from this that the stem, which is very well preserved, consists of a central area of steles and a rather thick sheath of cortex. These steles, which are several, are radiating plates or flattened strands of xylem presumably surrounded by phloem and pericycle, although these latter tissues are not preserved. As is indicated more clearly by Figure 1, some of the steles are highly curved and form narrow U- or V-shaped masses, the extremities of which abut on the periphery of the stelar area.

The protoxylem groups occupy immersed positions in the distal or peripheral portions of the steles and in the instance of the strongly curved and forked strands these groups may be several. The position of the protoxylem is marked by a cavity or loop, the delicate tissue usually being disorganized. These loops are well shown in both Figures 1 and 2.

As regards the mass of the xylem, it is for the most part primary. A limited amount of secondary growth occurs on the periphery of a few of the steles but is of very limited extent. Since longitudinal sections are not available it has been impossible to make a detailed study of the pitting. However, at a few points in the transverse section contortion of the tissue is sufficient to expose short portions of the tracheids obliquely, so that it can be stated with confidence that the pitting is scalariform.

As has been previously indicated, the zone referable to the phloem is very poorly preserved, only occasional vestiges of tissue remaining. In general this area conforms in its outlines to the contour of the xylem, and the tissue must have occupied the deep embayments between the xylem plates as well as a limited zone around the periphery. Very few observations have been made, in fact, on the phloem of any species of *Cladoxylon*, owing to the almost invariably poor preservation.

The cortex consists of a broad zone of thin-walled, large-lumened tissue, apparently of parenchymatous nature. Locally the cell walls may appear thickened, but this is due to masceration and swelling. In the type specimen of *Cladoxylon mirabile* from Saalfeld in Thuringia, Solms-Laubach[3] states the cell walls of the cortical tissue are thickened and somewhat fibrous. However, it is probable that this is due to the preservation, for Solms-Laubach mentions in the same account that the Saalfeld material characteristically shows a swelling of the cell walls with resulting diminution in size of the lumens.

[3] SOLMS-LAUBACH, H. GRAF ZU. *Ueber die Seinerzeit von Unger beschriebenen strukturbietenden Pflanzenreste des Unterculm von Saalfeld in Thüringen.* K. preuss. geol. Landesanstalt, p. 53. 1896.

The peripheral edges of several of the strands are marked by the presence of small, annular masses of xylem apparently departing in the manner of leaf traces. Here again the preservation is poor, so that it is impossible to describe these structures in detail. At several points in the cortex there are similar concentric areas of disorganized tissues which suggest leaf traces. More material is necessary, however, to determine the details of these.

An examination of the available figures of the several species of *Cladoxylon* suggests a comparison with *Cladoxylon* (*Arctopodium*) *radiatum* Unger. The published figures are not sufficiently definite to tie the two together, however. Further, Dr. Paul Bertrand, who has made a detailed study of the Saalfeld Cladoxylons, has examined the specimen here under discussion and is inclined to regard it as new. In consequence the name *Cladoxylon dawsoni* has been given this specimen in honor of the eminent Canadian paleontologist who first described it.

The interest of this fossil lies at present not so much in its structure, which naturally cannot be completely worked out with the scanty material at hand, but rather in its occurrence in the New York Devonian in the same beds with several species of *Callixylon* that Arnold[4] has described. It is regrettable that this record of Dawson's has been overlooked for so long.

As regards affinities, it will be recalled that specimens of the genus *Cladoxylon* have excited speculation as to their phyletic position ever since their discovery by Unger in Thuringia. Ascribed variously to the Pteridophyta and the Cycadofilicales, published investigations have not yet definitely proven their relationships. The discovery by Kräusel and Weyland of the leaves of *Cladoxylon scoparium* in strata of Middle Devonian age near Elberfeld, Germany, has, however, cleared up certain points. In this plant, identified by its stem structure, the leaves are spirally arranged and are small, petiolate, divided, and forked organs, the venation of which has not been determined. In addition to these sterile leaves there are fertile leaves—sporophylls—fan-shaped and lobed and with the distal edges hollowed to form numerous cup-shaped depressions which suggest marginal sori. Associated with these are the remains of numerous sporangia and spores.

Bertrand[6] has discussed in several short papers the possible rela-

[4] ARNOLD, C. A. *The genus Callixylon from the Upper Devonian of central and western New York.* Michigan Acad. Sci. Papers **11**: 1–50, pls. 1–19, 1 text fig. 1929 (1930).

[5] KRÄUSEL, R., and WEYLAND, H. *Beiträge zur Kenntnis der Devonflora*, Pt. 1. Senckenberg. Wiss Mitt. Bd. **5** (Heft 5–6): 154–184. 1923. *Beiträge zur Kenntnis der Devonflora*, Pt. 2. Senckenberg. naturf. Gesell. Bd. **40** (Heft 2): 113–155. 1926.

[6] BERTRAND, PAUL. *Sur les stipes de Clepsydropsis.* Compt. Rend. Acad. Sci. Paris **147**: 945–947. 1908. *Observations sur les Cladoxylées.* Assoc. franç. Av. Sci., 40th Sess., pp. 506–509. 1911. *État actuel de nos connaissances sur les genres "Cladoxylon" et "Steloxylon."* Assoc. franç. Av. Sci., 43d Sess., pp. 446–448. 1914. *Observations sur les Cladoxylées de Saalfeld.* Compt. Rend. Acad. Sci. Paris **195**: 1303. 1932. *Valeur morphologique du rachis primaire des Cladoxylées et des Zygopteridées.* Compt. Rend. Acad. Sci. Paris **196**: 364. 1933. *Specifications des Cladoxylon et des Clepsydropsis de Saalfeld.* Compt. Rend. Acad. Sci. Paris **196**: 365. 1933.

tionship of *Clepsydropsis antiqua* (a fern-like petiole) to *Cladoxylon* and has outlined a phyletic series connecting the Cladoxyleae with the Zygopterideae. The most important of these intermediates is *Asteropteris noveboracensis* Dawson. This note is scarcely the place for a discussion of these views, so it must suffice for the present to say that the evidence is quite suggestive although not conclusive.

This single specimen of *Cladoxylon dawsoni* is from the Genundewa limestone member of the Upper Devonian Genesee shale in the vicinity of Canandaigua Lake in western New York. At Saalfeld, Thuringia, the several species of *Cladoxylon* occur in strata regarded as Upper Devonian (*Cypridina* shales) in age.

ENTOMOLOGY.—*Some new Gyponas with notes on others.*[1] E. D. BALL, University of Arizona.

The writer made a preliminary revision of this group in 1920[2] with keys to the subgenera and species. With several years of additional biological work on the Eastern and Florida forms, Ball and Reeves[3] made still further revisions and gave the food plants and distribution as far as then known. Since coming to Arizona, the writer has continued the food plant studies and made further collections. These have so increased the number of species in one group that a new key is necessary.

KEY TO THE GENUS GYPONANA BALL (IN THE U. S.)

A Margin of vertex produced and foliaceous throughout.
  B No black spots on pronotum or hinge. Reticulations absent on basal part of elytra or, if present, no white flecks between.
    C Species large, broad bilineate.....1-*octolineata* Say
    CC Species smaller, narrow, pale.....2-*tenella* Sign
  BB A pair of block spots on pronotum and another pair on the hinge (sometimes wanting), elytra densely reticulate (rugose) with white flecks between.
    D Head almost as wide as pronotum, the vertex broad and rounding, species large, with long rounding elytra.
      E Species without a black line under vertex.
        F Vertex slightly produced beyond the eyes then rounding, female segment with a rectangular median notch. (S.E.), 3-*rugosa* Sign
        FF Vertex rounding from the eyes, female segment with two oblique upturned thumb-like projections.....
        .....(Ariz.), 4-*ampliata* Ball

[1] Received August 14, 1935.
[2] Annals Ent. Soc. Amer. 13: 83–100. 1920.
[3] Annals Ent. Soc. Amer. 20: 488–500, 2 pl. 1927.

EE A black line under vertex margin, appendix broadly smoky and the male pygofers scarlet.....(Ariz.), 5-*pullata* Ball

DD Head definitely narrower than pronotum, which narrows anteriorly, vertex more or less angled.

G Vertex obtusely angled or almost rounding.

H Vertex very obtusely angled, species tawny green.....(Ariz.), 6-*ramosa* Kirk

HH Vertex almost a right angle, species pale.....(Ariz. & Utah), 7-*turbinella* Ball

GG Vertex right angled or acutely angled, species powdered.....(Utah), 8-*chadana* Ball

AA Margin of vertex and front angled, but not foliaceous.

I Small species (about 2 mm. wide), vertex about twice as wide as long.

J Extremely elongate with two oblique stripes on each elytron.....(Calif.), 9-*elongata* Ball

JJ Normal shape and without stripes...(Ariz. N. Mex.), 10 *delta* Ball

II Large species (about 4 mm. wide) vertex three times as wide as long.....(S.W.), 11-*dorsalis* Sign

*Gyponana rugosa* Spang. This eastern species has not appeared in Arizona except in the higher mountain regions of the N. E. portions, which is the region of the deciduous oaks.

**Gyponana ampliata** Ball n. sp.

Big broad tawny-green, heavily reticulate with milky spots and the usual black dots on pronotum and hinge, closely resembling *rugosa*, paler, with the vertex rounding from the eyes, instead of produced and then rounding. Length ♀ 10 mm., width 3.5 mm.

Head practically as wide as pronotum, vertex shorter than pronotum; rounding directly from eyes, elytra broad, densely and evenly reticulate with apices rounding and appendix narrow. Female segment with the customary median quadrangular notch almost obliterated by the semicircular emargination of the lateral portions of the segment leaving oblique, thumb-like projections, which would form the margin of the notch if they were not turned up at right angles against the pygofers. The median portion broadly, shallowly bilobed. Male plates very narrow and widely separated at base, the inner margins broadly expanded, then narrowing to the rounding apices, beyond which the dark, spine-like styles project. In *rugosa* the plates are approximately parallel margined, 3 times as long as wide, and cover the styles.

Holotype[4] ♀ and 2 paratypes Santa Rita Mountains, July 6, 1933, allotype ♂ Chiricahua Mountains July 5, 1930, four paratypes Huachuca Mountains, June 15, 1930, and one Santa Rita Mountains, June 20, 1929, (labeled Tucson). All taken from oak in the high mountains of Southern Arizona by the author, most of them from the silver leaf oak (*Q. hypoleuca*). This species can be recognized by the very distinct genitalia of either sex.

[4] All types are in the author's collection.

**Gyponana pullata** Ball n. sp.

Resembling *ampliata*, but much narrower and more nearly parallel margined. Darker with a black line under the vertex and a broad, smoky appendix. Length ♀ 9 mm., width scarcely 3 mm.

Slender, parallel margined. Head as wide as pronotum, vertex as long as *ampliata*, but narrower so that it is more acutely rounding. Elytron long and narrow with rounding apex and a broad, smoky appendix. Female segment with a broad notch occupying nearly one-half the segment, the margin of the notch rounding back to the lateral angles, base of notch nearly filled by a broad bilobed pyramid that extends nearly as far as the segment. Male plates 2½ times as long as their individual width, each one convex below and angularly pointed, much exceeded by the long slender slightly knobbed styles. Pygofers and margins of abdomen scarlet.

Holotype ♀ and allotype ♂ Santa Rita Mountains July 6, 1933, nine paratypes taken with the types and in the Chiricahua and Huachuca Mountains, all taken by the author from the silver leaf oak in the mountains of southeastern Arizona.

This is the species Gibson keys out as *ramosa* Kirk, but cannot be the one Kirkaldy had in hand, as he does not mention the black line on vertex and states definitely that it had no appendix while this one has a broad appendix. This species does not occur at Nogales which is below the range of the silver leaf oak. The black line on vertex, smoky appendix, and red pygofers in the male, as well as the distinct genitalia, will easily separate this species. It rather strikingly, but superficially resembles the green males of *Gypona verticalis* in color and shape, but the reticulate elytra places it in a different group.

*Gypona ramosa* Kirkaldy. A narrow-headed species with a slightly angular vertex, but little over half as long as its basal width, a very narrow appendix and often showing a dark line around the apex of each elytron. They are pale green, without the tawny reflection, and heavily white flecked. A few of them show traces of a sinuate dark band on pronotum but this character is not constant in any known species. The female segment has the median third deeply roundingly emarginate, with a bilobed tooth two-thirds the length of the notch.

Through the kindness of Mr. E. P. Van Duzee, we have examined the Gyponas of the Koebele collection from which Kirkaldy described this species. There were ten examples of a single reticulate-veined species. This proved to be the common form found on the two oaks (*Q. emoryi* and *oblongifolia*) that grow in the Nogales region. This species answers Kirkaldy's description in every particular and as suggested previously, the slightly angulate vertex, lack of appendix and deeply bisinuate female segment definitely eliminates the species described above as *pullata* on which Gibson placed the name.

**Gyponana turbinella** Ball n. sp.

Resembles *chadana*, larger, broader, with a broader vertex, slightly smaller than *ramosa* with a much longer and more strongly angled head. Pale green,

with white fleckings and a very slightly obtusely angled vertex. Length ♀ 8 mm., width 3 mm.

Head almost as long as the width between the eyes, narrower than the base of pronotum, vertex slightly shorter than pronotum, slightly obtusely angled, instead of acutely angled as in *chadana*. Elytra broad, rounding posteriorly, instead of narrower and almost acutely angled, as in *chadana*. Female segment with a narrow shallow notch with sloping margins, the median feebly bilobed projection about as long as segment. Male plates long, silky, gradually narrowing to rounding apices that exceed the slender pale styles.

Holotype ♀, allotype ♂ October 6, 1929 and six paratypes of various dates, Granite Dell, two from Yarnell Heights, and four from Superior, August 1, 1929. All taken by the author from the Chaparal oak (*Q. turbinella*) in the mountains of Arizona. This is the common species in the Chaparal region from Globe to Williams, Arizona, and appears again around St. George in Utah. The long, definitely triangular head will separate it from all but *chadana*, in which the head is still more pointed and the whole insect is covered with a whitish bloom.

**Gyponana elongata** Ball n. sp.

Still longer and narrower than *tenella*, with a head as wide as the pronotum. Pale green with four black stripes on the elytra. Length ♀ 7.5 mm. width 1.8 mm.

Head much wider than in *tenella*, as wide as the pronotum, eyes small, vertex broad, the anterior margin paraboloid or a trifle angled, the margin rather thick and short, scarcely foliaceous. Pronotum, with the lateral margins long and almost parallel, scarcely longer than the vertex. Elytra very long and slender, tapering toward the rounded apices—a few coarse, tawny reticulations scattered along posterior half of corium. Female segment scarcely longer than the adjoining one, broadly roundingly or slightly angularly emarginate, the lateral angles acute. Sometimes a median projection is faintly indicated. Male plates extremely long and slender, slightly tapering.

Color: Pale creamy, with a greenish tinge, ocelli red, a pair of widely separated dark dashes on the scutellum. A black stripe just outside the claval suture and another outside the inner fork of the outer sector. A smoky line around the apex. Below pale creamy.

Holotype ♀, allotype ♂, and eleven paratypes taken by the writer from Red Shanks (*Adenostoma sparsifolium*) at Pine Valley, California, July 6, 1931. Strikingly distinct on account of the black stripes.

**Gyponana delta** Ball n. sp.

Resembling *tenella*, but paler with a more angular head and a "U" shaped notch in the female segment. Extremely pale green fading to creamy translucent. Length ♀ 8 mm., width 2.5 mm.

Head definitely narrower than pronotum, the vertex roundingly angled with the apex bluntly rounding, the margin thick and not foliaceous. Vertex quite variable in length, varying from scarcely 2/3 to nearly the length of pronotum. Elytra about as in *tenella*, with very little reticulation. Female segment rather long with the lateral margins narrowing, the lateral angles rounding, posterior margin elevated over the ovipositor with a deep "U" shaped or slightly angular notch extending nearly half way to the base.

Male plates long, slender, tapering, exceeding the pygofers, but exceeded by the sickle like white styles. The inner margins of the plates are thickened and reflexed and there is a row of long white spines towards the tip.

Holotype ♀, allotype ♂, and 7 paratypes taken on snake weed (*Gutierrezia sarothrae*) at Paradise, Arizona. Six paratypes taken on *Mortonia scabrella* at Tombstone, Arizona, June 13, 1932, all taken by the author. In the angulate head this species resembles *Gypona angulata*, but that is a larger species with simple segment and no reticulations.

**Gyponana delta** var. **alomogorda** Ball n. var.

Form and structure of the species, but nymphs and adults powdery white, the darker hind wings slightly showing through the elytra.

Holotype ♀, allotype ♂, and seven paratypes taken by the writer May 5, 1933, on a powdery white mint (*Paliomintha incana*) growing on the white sands at Alomogorda, New Mexico.

*Gypona villior* Fowler is closely related to *verticalis* and like that species has males ranging from green all the way to black. The extremely large and prominent veins of the elytra are its most distinctive character. Nymphs and adults have been taken by the writer on the Apache plume (*Fallugia paradoxa*) from Prescott to the Huachuca and Chiricahua Mountains in Arizona.

*Gypona melanota* Spangberg. The study of a larger amount of western material in *unicolor* indicates that the broad, short eastern species is distinct from the longer Rocky Mountain one. *G. melanota* described from black males from New Jersey and Georgia is apparently the oldest name available for the eastern species.

*Prairiana orizaba* Ball and Reeves. This extremely long, slender Mexican species with the acute vertex has been taken by the writer (males only) from Brownsville, Texas; Granite Dell, and Santa Rita Mountains, Arizona.

*Prairiana moneta* Van Duzee. The writer has taken this California species with its broad foliaceous head and smoky male, at Bunkerville, Nevada; Yuma and Phoenix, Arizona. They have all been swept from Bermuda grass in low, damp, alkaline areas and at low elevations.

**Prairiana sidana** Ball n. sp.

Smaller and narrower than *moneta* Van Duzee with a more acute, but less foliaceous head. Dead grass color in the female with the posterior margin of pronotum and all back of that smoky to shining black in the male. Length ♀ 7 mm, width 2.8 mm; male smaller.

Head slightly narrower than pronotum, the marginal line of pronotum and vertex continuous. Vertex nearly paraboloid, slightly acutely angulate in male, as long as pronotum, much longer proportionally to its width than in *moneta*. Front more inflated than in *moneta*, the vertex margin only slightly foliaceous across front. Elytra short, rather broad in female, nearly parallel margined in the male, exceeding abdomen by less than the apical cells. Female segment bisinuate, the median lobe much smaller than in *moneta*. Male plates long, strap shaped, their points divergent, much longer than the dark spine-like styles. Pygofers angled, but not as acutely as in *moneta*.

Holotype ♀, allotype ♂, and 8 paratypes taken by the writer from a prostrate mat-like mallow (*Sida diffusa*) growing under the short grasses on the range slopes of the Baboquiviri Mountains, Arizona, August 29, 1931, and four paratypes taken under similar circumstances at Patagonia, Arizona, September 20, 1930.

There is no question but what the coloration of this and the other species of *Prairiana* is an adaptation to concealment in dead grass, but the food plant of this species is definitely the mallow creeping below the grass. Most of the species of this genus are more restricted than grass inhabitants usually are and it will probably be found that that restriction is due to food plants growing beneath the grass cover. In the case of *subta* both larvae and adults were found beneath a clump of grass on the plains of Colorado, but there was a mallow (*Malvastrum*) scattered all through the area.

**Ponana sonora** Ball n. sp.

Resembling a small pale *citrina*, straw-colored with a very narrow angulate head and six black spots in a semicircle. Length ♀ 8 mm, width 2.2 mm.

Head extremely narrow, scarcely wider than scutellum; vertex sloping, obtusely angled, one-half wider than long, the anterior margin rounding over to front, much broader than in *citrina*. Ocelli very large, scarcely their own width from the front margin of vertex and midway between the eye and the median line. The front inflated, strongly convex in both diameters; pronotum half longer than the vertex, broad behind, the lateral margins narrowing so rapidly as to form a semicircle with the front margin. Elytra more nearly parallel margined than in *citrina*. Female segment feebly bisinuate; male plates elongated spoon-shaped emarginate near the apex, concealing pale, slender styles with out-turned sickle-like tips.

Color: pale creamy or greenish straw. The ocelli very large and dark red, pronotum with four black spots on the submargin, which, with those on the hinges, form a semicircle. In the darkest specimens the disc of the pronotum is covered with minute dark points. Elytra uniform subhyaline straw with a smoky spot beyond the apex of clavus. Occasionally the eight points appear on the elytra as in *citrina*.

Holotype ♀ and allotype ♂ Santa Catalina Mountains, Arizona, September 19, 1930, and 9 paratypes taken at the same place at various dates from April on. The writer took these, with their white-haired nymphs, from a white-leaved perennial mallow (*Abutilon incanum*) growing on the south slopes of Sabino Canyon.

*Ponana dohrni* Signoret. The writer has taken nymphs and adults of this species from the white sandbar-willow (*Salix exigua*) in a number of places in southern Arizona. They are especially common on second growth sprouts.

*Ponana candida* Van Duzee, described from the Gulf of California, has been taken by the writer at the High Tanks on the Mexican border in Arizona. This beautiful black and white species was found as large nymphs and adults May 17, 1936, feeding on a six-foot white mallow (*Horsfordia alata*).

*Ponana curiata* Gib. The writer took a number of adults of this species

from a woody mat-like composite at the control station on the way up to Mt. Lemmon, Arizona, August 15, 1931. He took a pair at Redondo Beach, California, July 4, 1931, on a hairy, aster-like plant, (*Heterotheca grandiflora*).

*Ponana marginifrons* Fowler. This long, strikingly marked species with heavily margined nervures has been taken in abundance, both nymphs and adults, from the three-leaved sumac (*Rhus trilobata*). It is found in S. W. Colorado, S. E. Utah, Arizona and New Mexico, south into Mexico.

**Ponona marginifrons var. suilla** Ball n. var.

Head form and genitalia of *marginifrons* nearly. Size, shape of body and short elytra of *resima* Fowler. Uniform pale cinnamon with powdered elytra and greenish costa. Length ♀ 8 mm, width 3 mm.

Head about as in *marginifrons*, the vertex less sloping, slightly more angulate with the margin upturned like a hog's snout. Elytra much shorter and broader than in *marginifrons*, about as in *resima*, but without the prominent nervures of either. Females segment of an entirely different pattern from that of *resima*, but resembling *marginifrons* in the acute lateral angles, and the angularly produced median portion with a heavily chitinized projection at the apex.

Color: strikingly distinctive, uniform pale cinnamon. The elytra pruinose with the basal half of the costa greenish, the nervures concolorous. There are no spots or markings, except sometimes the round black dots back of the eyes and dash on hinge that are typical of the group.

Holotype ♀, and one paratype female from the Pinal Mountains above Superior, Arizona, August 1, 1929. Allotype ♂ and two paratype females from the same place July 11, 1935. All beaten from Chaparal Oak (*Q. turbinella*) by the writer.

In appearance this form is quite distinct and resembles *resima*, but in structure, except for wing length, it is close to *marginifrons* and will probably be found to be an adaptation to its food plant.

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## PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

### GEOLOGICAL SOCIETY

#### 522ND MEETING

The 522nd meeting of the Society was held in the Assembly Hall of the Cosmos Club, January 9, 1935, President W. T. SCHALLER presiding.

*Informal communications.*—JEWEL J. GLASS described what is probably the largest known zinnwaldite (a rare variety of mica) crystal, the portion recovered alone weighing 24 pounds. It was found at the Morefield mine in the celebrated pegmatite region near Amelia Court House, Virginia. This mine has also produced germanium-bearing topaz crystals of unusual size, some weighing as much as 500 pounds.

GEORGE OTIS SMITH described crack systems in river ice in Maine due

principally to changes of level of the water. Very little movement was found along the cracks. Although offsets of certain cracks occurred along other cracks these did not indicate lateral motion of the ice blocks. Discussed by G. F. LOUGHLIN.

M. A. PENTZ described the stratigraphic sequence of rocks and clays found by boring in the Carolina bays. No evidence was found supporting a meteoric origin of the Carolina bays; the sediments lie undisturbed at a shallow depth.

*Program.*—EDWIN D. MCKEE: *Some observations on the Middle Permian marine formations of northern Arizona.* The numerous lithologic types included in the formation known as the Kaibab limestone, in northern Arizona, include marine sandstones, bedded cherts, "redbeds," white cross-bedded sandstones, gypsum deposits, and several types of limestones. The complex interrelationships between these various types and the transitions from one type to another may be observed and traced in numerous localities in this region, especially along the walls of the Grand Canyon and the Little Colorado Canyon. Here then is found an exceptionally fine area for determining various features of Permian deposition. In a section of normal Kaibab limestone there are three distinct limestone units or members characterized by distinctive lithologic and faunal elements. These are separated from one another by sandstones and probably represent distinct invasions of the sea. The limestones and intermediate sandstones control to a great extent the development of topographic features, and are well expressed in typical canyon profiles of the region. In each limestone member of the Kaibab formation the fauna is represented by two facies. These are best described as the normal open sea facies, with brachiopods of the *Productus* group predominating, and the brackish water facies composed of pelecypods and gastropods with *Bellerophon* most conspicuous.

The lower member of the Kaibab limestone is separated from the middle limestone or upper cliff-forming member by an unconformity which has been noted in several localities. The hiatus represented probably is not great but involves a time of slight erosion before the second sea invaded the area. The uppermost limestone differs greatly in lithologic character from the middle limestone and is separated from it over wide areas by a relatively thin bed of crosslaminated sandstone. No evidence of an erosional break has been noted between these limestones but the contrast between their faunas is marked. The details concerning the nature of the transitions which occur both vertically and laterally between the sandstones, limestones, bedded cherts, and gypsum deposits are best brought out by three series of sections made along general east-west lines located (1) through the deep canyons south of Flagstaff, Arizona, (2) along the rim of Grand Canyon, and (3) near the Arizona-Utah border. The work on this problem is still in a preliminary state, but enough has been done to indicate many significant features regarding Middle Permian sedimentation, paleogeography and ecological conditions. (*Author's abstract.*) Discussed by Messrs. BUTTS, MERTIE, MISER, GOLDMAN, HENBEST.

G. A. COOPER: *Stratigraphy of the Tully limestone, New York.*

J. C. REED and J. M. HANSELL: *Quicksilver deposits near Little Missouri River, Southwest Arkansas.* Cinnabar was discovered near the southern border of the Ouachita Mountains in southwestern Arkansas in 1930 but was not identified until June 1931. The quicksilver district is now known to have an east-west length of about 30 miles and an average width of less than a mile. The part covered in this paper is concerned with a 12-mile segment of the district near the Little Missouri River, and includes the 3 mines, Gap

Ridge, Parker Hill, and Parnell Hill, from which most of the production to date has come. The principal rocks exposed in the district are shale and sandstone of the Atoka, Jackfork, and Stanley formation, of Pennsylvanian age, which aggregate many thousands of feet in thickness. The rocks have been deformed by close folding and thrust faulting and the three formations form several east-northeast trending belts.

All the cinnabar deposits are in a northward overriding thrust block that is cut by northeast trending cross faults and is deformed and fractured by cross folds. The cross folding has not yet been adequately explained but it apparently is related to the thrusting. The cross faults appear to be tear faults formed during the thrusting. Mineralization occurs principally in a sandstone member of the Stanley shale but locally is found at other horizons in the Stanley and in the overlying Jackfork sandstone. The cinnabar fills fractures related to the cross folding, and the linear distribution of the ore occurrences is believed to have been due to mineralizing solutions ascending along the thrust fault until they reached fractured sandstones of the Stanley whence they followed these permeable beds toward the surface. Some of the cross faults may be worthy of prospecting. (*Authors' abstract.*) Discussed by Messrs. WASHBURNE, HESS, FERGUSON, HENDRICKS, MISER, HEWETT.

## 523RD MEETING

The 523rd meeting was held in the Assembly Hall of the Cosmos Club, January 23, 1935, President SCHALLER presiding.

*Informal communications.*—H. D. MISER reported that the urgent need for more manuscript papers to be published in the Bulletin of the American Association of Petroleum Geologists had been brought to the attention of the Geological Society of Washington. Authors having suitable manuscripts may submit them to Mr. J. P. D. HULL, Business Manager, Box 1852, Tulsa, Okla.

D. F. HEWETT stated that in connection with field work in the mineral resources near Boulder Dam during the spring of 1934, observations were made on the north and south ends of Avawatz Mountain which show that post-Miocene thrust faulting on a large scale is present west of the Death Valley trough as well as east of it. The Garlock fault is interpreted as a tear fault which turns southward around Avawatz Mountain and limits a block of pre-Cambrian gneiss that is thrust over Miocene sands and volcanic rocks.

*Program.*—L. W. CURRIER: *Structural features of the Illinois-Kentucky fluorspar field.* The areal structural pattern due to doming and normal faulting, together with the unusual occurrence of numerous igneous bodies, led to an earlier belief by several geologists that the uplift of the region resulted from a deep-seated intrusion of magma, and that the faults represent a subsequent settling of the dome. The striking symmetry of the Hicks dome, a small structure in the northwest part of the field, is highly suggestive of a laccolithic intrusion, but the general fault pattern of the field as a whole seems more clearly a result of broader regional warping because (1) of the lack of a concordant relation between the fault trends and the longer axis of the dome, (2) the general absence of dikes from fault fissures, (3) the offsetting of dikes by faults of the prevailing northeast-southwest system, and (4) the continuance of narrow faulted belts from this area to southeast Missouri on the west, and central and eastern Kentucky on the east. It seems likely that the area experienced regional warping, effects of which were local emplacement of the magma beneath the domed area, and intrusion of the dikes; continuing or later crustal disturbance imposed the major

fault systems, and in these fissures were deposited vein minerals of hydrothermal origin. Incidentally, an interesting suggestion has been made by Bucher, who speculates concerning an incipient geosynclinal trough involving the upper part of the Mississippi embayment area. The axis of this trough had it developed beyond the embayment, would, according to him, probably have followed the zones of crustal tension now marked by fault systems that extend eastward from the fluorspar field into central and eastern Kentucky. It is to be noted that the highly fractured fluorspar field lies at a sharp bend in this postulated axis.

An interesting recent development has been the exploitation of another type of fluorspar deposit, designated by some as "blankets," and by others as "bedded deposits." The connotations of these terms are misleading and the writer prefers to call them "bedding replacement deposits" since it is believed that they were formed by the replacement of limestone along bedding planes, directly beneath impervious shale or dense limestone beds. These deposits are not obviously connected with prominent faults, but recent work seems to indicate that solutions arose along minor fractures of little or no displacement, connected with minor faults, and these in turn with a major fault zone. Solutions rising along small fractures in the locally warped Cave in Rock fluorspar district were impounded or greatly impeded beneath the impervious beds, and lateral replacement of the limestone took place with preservation of the bedding of the limestone producing a "coon-tail" type of banded ore. The writer dissents from the "diffusion banding" theory of Bastin as a major process for several reasons that will be treated in a later paper. (*Author's abstract.*)

M. KING HUBBERT: *Determination of certain structural features in Illinois, Kentucky, and Alabama by electrical resistance methods.* The work herein discussed was conducted chiefly during the summer of 1934, though it was a continuation of work begun earlier for the Illinois State Geological Survey. Two distinct areas were involved: (1) the fluorspar-bearing district of southern Illinois and of northwestern Kentucky, and (2) the limonite iron-bearing area around Russellville in northwestern Alabama. Most of the work was done in the fluorspar region and only a short amount of time was devoted to experimental work in Alabama. Three methods were used: (1) the Wenner four-electrode technique with Gish-Rooney apparatus for the determination of specific electrical resistivity of the ground. (2) equipotential-line mapping, and (3) potential-drop-ratio depth correlations.

The resistivity method was used for locating faults in Illinois and Kentucky. The resistivity of the rocks on the opposite sides of a fault is frequently quite different. This fact enables one to locate faults not otherwise known by making cross-country traverses on which resistivity measurements effective to depths of the order of 100 feet are taken at intervals of 100 feet. Faults are frequently disclosed by abrupt changes in the readings of specific resistivity in these traverses.

An equipotential-line map was made of one area in Kentucky which was crossed by a dike and by a complex of faults, and was known to be fluorspar and galena bearing. Most of the faults produced no noticeable effects. One fault, however, produced a very severe distortion of the equipotential lines. These lines in this case changed direction abruptly in the vicinity of the fault and ran parallel to it for a distance of 100 feet or more. This indicated a very highly conductive zone along this fault. Galena is the only mineral common to the area which seems sufficiently conductive to account for this anomaly.

Work by the potential-drop-ratio method was conducted in Alabama. The stratigraphic column there was: Chert gravel underlain by limonite with massive limestone beneath. All of these, it proved, were very highly resistive with very little contrast. Numerous depth profiles by the potential-drop-ratio technique gave a faint correlation, but one not distinct enough to make the method seem reliable as a potential substitute for test holes in locating ore. (*Author's abstract.*) Contributors to the discussion of the two papers of the regular program at the conclusion of the second were: Messrs. SCHALLER, HENDRICKS, BASTIN, FERGUSON, GOLDMAN, HEWETT, R. C. WELLS, HENBEST.

### 524TH MEETING

The 524th meeting was held in the Assembly Hall of the Cosmos Club, February 13, 1935, President SCHALLER presiding.

The following resolution was presented by Dr. T. W. STANTON and unanimously adopted by the Society: WHEREAS, Dr. DAVID WHITE, a charter member and Past President of the Geological Society of Washington, died at his home in this city February 7, 1935, at the age of 72, it is fitting that the Geological Society should pause for a moment in tribute to the memory of one whose splendid character, innate ability and outstanding accomplishments in the broad and varied fields of his life work have been and are an inspiration to all who knew him. As another colleague has said of him, Dr. White "has long been the foremost Paleozoic paleobotanist on this continent and perhaps in the world. His work here was not merely systematic and descriptive but was interpretative from the beginning. He was a stratigraphic paleontologist of the highest rank. He was our foremost authority on the origin and evolution of coal. His great generalization, known widely as the carbon ratio hypothesis, was an outgrowth of his studies on the origin and evolution of both coal and petroleum. It established a 'dead line' beyond which oil pools will not be found. This has great economic significance. It alone stamps him as a rare original investigator and thinker. He contributed significantly in the field of isostasy. He administered an important unit of government during the Great War in such fashion as to make it most useful during the crisis." These quoted words suggest only a few of the varied fields in which he excelled. Here in the presence of his friends it is not necessary to enumerate the many honors and responsibilities that came to Dr. White during his life time. They were all received by him most modestly. To those of us who have known him through most of his long service in Washington—almost half a century—he was an inspiring leader, a helpful counsellor, an ever faithful friend.

THEREFORE, it is moved that these few and most inadequate words of appreciation be incorporated in the minutes of this meeting and that the Secretary be instructed to convey to Mrs. White the sincere sympathy of the entire membership, and a copy of these resolutions.

*Informal communications.*—C. S. Ross reported that the tentative conclusion that euhedral analcite resulted from the alteration of glassy volcanic ash, probably deposited in a saline lake, was confirmed by the recent studies of Bernard M. Moore. The material studied by both Ross and Moore came from the vicinity of Wikieup Post Office, western Arizona. Microscopic examination showed all stages in the alteration of glassy volcanic ash to a nearly pure analcite rock. One section showed tiny analcite grains forming within typical glassy ash grains. Discussed by Messrs. GOLDMAN, RUBEY, SCHAIRER, MILTON.

A. H. KOSCHMANN stated that work in slaty rocks in southeastern Alaska showed that the usual relationships between cleavage and structure—uniformity of dip and strike over large areas—did not apply. The cleavage varied from place to place within a short distance. In general it was found to be parallel to the limbs of folds. In extreme cases it was even found dipping in opposite directions in alternate layers varying from an inch up to one foot in thickness. Discussed by Mr. BRADLEY.

J. P. MARBLE stated that the Committee on Determination of Geologic Time desires to secure samples from fine-grained sills, flows or dykes of known geologic provenance, for examination of the "Helium Method" at the hands of Dr. W. D. URRY, of the Massachusetts Institute of Technology. Samples should be from fresh exposures, and not taken from or near old surfaces. They should be sent to Prof. A. C. LANE, Chairman, Tufts College, Cambridge, Massachusetts, or to J. P. MARBLE, U. S. Geological Survey.

*Program.*—P. D. TRASK and H. E. HAMMAR: *Organic content of sediments.* This paper has been published in full in Proceedings of the American Petroleum Institute Production Bulletin 214, 1934, and in the Oil and Gas Journal, vol. 33, no. 27, pp. 43–46; no. 28, pp. 40–41; no. 29, pp. 36–39, Nov. 22, 29, Dec. 6, 1934. It is essentially a progress report which presents data about the distribution of organic matter among sediments from several oil-producing areas in California, Wyoming, Colorado, Montana, Kansas, Oklahoma, and Texas. The report explains briefly the methods of determining the organic content of sediments; and one method, that of ascertaining the degree of oxidation by means of chromic acid, is described in detail. Sediments, in general, contain little organic matter. The average organic content is about 1.5 per cent, and relatively few sediments contain more than 4 per cent. Since the average organic content of recent marine sediments is about 2.5 per cent, it would seem as if the loss in organic matter during burial is of the order of magnitude of 50 per cent. The scarcity of sediments containing more than 4 per cent organic matter indicates that a large organic content is not required for the generation of petroleum in commercial quantity, even in consideration of the fact that the organic content of the sediments is less now than at time of deposition. However, the association of so many oil horizons with sediments, like the Miocene of California, the upper Cretaceous of Wyoming, the Cherokee shale and Chattanooga shale in Oklahoma, and the Eagle Ford shale in Texas, which contain considerable more organic matter than the general average for sediments, indicates that relative richness (but not necessarily extreme richness) is a favorable indication of source beds. On the other hand, the organic content is not an absolute index of source beds; as some rich sediments are not associated with oil horizons, and some oil horizons are not associated with rich sediments. Evidently other factors, like the volatility, the degree of reduction of the sediments, or the ease of migration of oil out of the sediments, have to be considered. In fact, some of the data already obtained seem to indicate that comparatively high volatility and high degree of reduction are favorable indications of source beds. (*Authors' abstract.*) Discussed by Messrs. SCHALLER, WELLS, FAHEY.

P. J. SHENON: *Utah earthquake of March 24, 1934.* An earthquake of major intensity which centered near Kosmo, Utah, at the northern end of Great Salt Lake, was felt in 4 states over an area of about 150,000 square miles on March 24, 1934. The first and strongest shock was felt for 650 miles in an east-west direction and for 400 miles in a north-south direction. The intensity in the epicentral area was 8 to 8+ of the Modified Mercalli scale of

1931 and 8+ to 9− of the Rossi-Foral scale. The first shock was recorded in the epicentral area at 8:06 A.M., M.S.T. It was followed by hundreds of aftershocks but no foreshocks were reported. The earthquake was strong enough to alarm inhabitants throughout an area having a radius of nearly 100 miles. Many people became dizzy or nauseated and most people became very sensitive to the smaller shocks that followed the first disturbance.

Considerable property damage as well as loss of life was avoided only because of the sparsity of population in the epicentral area. All chimneys were shaken down in the epicentral area. Brick and stone buildings at Snowville were damaged and some damage was done as far away as Salt Lake City, where cracks developed in some office buildings. The tracks of the Southern Pacific railroad, 3 miles east of Kosmo, were displaced vertically about 4 inches.

A number of ground cracks developed in the epicentral area. Most of the fractures were in the salt flats or in poorly consolidated gravel and related rocks that probably belong to the Lake Bonneville sediments. The ground cracks extended in an east of north direction for at least 5 miles although no one fracture was continuous for a great distance. Rather there was a tendency for the cracks to develop en eschelon patterns. All of the fractures noted by the writer had nearly vertical dips and so far as known the movement along them was entirely vertical. Four distinct fractures crossed the road about 3 miles north of Kosmo. They were about ½ mile apart. The vertical displacement along these fractures ranged from about 2 inches to 20 inches and, except for one, all were displaced downward on the east side. The west side dropped about 3 inches along the fault which crossed the road nearest to Kosmo.

Numerous springs developed in the epicentral area as a result of the earthquake. So far as known all of them arose along well defined fractures and most of them formed in the salt flats. Where the flow was localized along fractures mud cones were built up at the surface. Some of the springs that developed during the earthquake flowed as much as 0.5 sec. ft. of water. It is believed that settling and readjustments in the saturated material along the old shore line of Great Salt Lake was responsible for the development of the springs.

The earthquake was probably caused by movements along faults in Hansel valley. All of the fractures showing displacements in the epicentral area were in gravel and related rocks; hence it cannot be definitely stated that they were not formed by slumping and settling as the result of earthquake vibrations. However, the close association of the fractures with the terraced forms and lines of old springs strongly suggests that the recent displacements followed old surfaces of movement. This in turn suggests that the fractures may have been caused by adjustments in the bedrock below and that the faults that define Hansel Valley are still active and that the recent earthquake was caused primarily by movements along these faults. This is supported by the fact that this vicinity has been an active seismic center for many years. (*Author's abstract.*) Discussed by Captain HECK and Mr. C. S. ROSS.

G. W. STOSE and ANNA I. JONAS: *An erosion remnant of a great overthrust sheet in the Highlands near Reading, Pa.* The Reading-Boyertown Hills of Pennsylvania are a part of the Appalachian Mountains and trend northeast between the Great Valley on the north and the Triassic belt on the south. From their western end in South Mountain, southwest of Wernersville, they are continuous across eastern Pennsylvania into the Highlands of New

Jersey and into New York. The present paper sets forth the results of a structural study of the Reading-Boyertown Hills north of the Triassic rocks during which the mapping of the Paleozoic rocks has been revised and extended and the overthrust nature of the mountain belt has been worked out.

The oldest rock in these mountains is a pre-Cambrian graphitic gneiss of sedimentary origin with marble lentils. It is invaded by an igneous complex also of pre-Cambrian age. The Lower Cambrian Hardyston quartzite, with an estimated thickness of 300 feet, unconformably overlies the pre-Cambrian rocks. It includes a basal arkosic pebbly quartzite overlain by thick-bedded vitreous quartzite, the upper part of which contains *Scolithus linearis*. The limestone of the Great Valley includes from the base upward Lower Cambrian Tomstown dolomite, Middle Cambrian Elbrook limestone, Upper Cambrian (Ozarkian of Ulrich) Conococheague limestone, and the Ordovician Beekmantown and Leesport limestones, overlain by Martinsburg shale of Trenton to Eden age.

The Irish Mountain mass and Lock Ridge, which form a front line of hills, are anticlinal uplifts of pre-Cambrian rocks and Lower Cambrian quartzite which dip normally under Cambrian (Tomstown) limestone. The rest of the mountain area from its end southwest of Wernersville to South Mountain south of Allentown, a distance of over 50 miles, and probably across Pennsylvania to Easton, is part of a great overthrust sheet, here called the Reading overthrust, which has ridden northwestward on a flat fault plane in its crystalline core over Lower Paleozoic rocks which are now exposed in Oley Valley and in many other mountain valleys. Evidence of the overthrust character of the mountain belt is based on structural and stratigraphic discordance of the mountain rocks with the adjoining rocks of the valley border, and mylonites on the borders of the thrust block where pre-Cambrian rocks and quartzites have been ground out into mylonites on the sole of the overthrust sheet.

Many small detached areas of the main overthrust sheet, or klippen, occur on the borders of the mountains. The largest is Neversink Mountain lying south of Reading, which is a narrow anticline of pre-Cambrian rocks bordered on both sides by much crushed quartzite. The older rocks of this mountain lie on Middle Cambrian (Elbrook) limestone. The mountains are dissected by many steep-sided flat-bottomed valleys in some of which limestone and quartzite are exposed. These valleys are interpreted as windows in the overthrust sheet which has been cut through by erosion to the underlying limestone. Evidence for this is in the blocks of chert found in most of the valleys, the chert having been formed by silicification of the limestone along the thrust fault, and the presence of granite and quartzite mylonites at the valley borders. The roots of the thrust are buried under the Triassic rocks dropped down by the Triassic border fault.

It is suggested that Jenny Jump Mountain, N. J., and the Highlands of New Jersey lying northwest of the Green Pond Mountain syncline of Silurian and Devonian rocks are part of the overthrust block observed in the Reading-Boyertown Hills. The Highlands of New York which lie southeast of the Green Pond Mountain syncline trend southwestward and pass under the Triassic sediments southeast of the strike of the overthrust sheet here described. The youngest rock involved in the overthrust is Martinsburg shale, hence the age of the movement is at least post-Eden. It is believed that the thrust is Appalachian in age. (*Author's abstract.*) Discussed by Messrs. C. S. Ross, H. D. Miser.

## 525TH MEETING

The 525th meeting was held in the Assembly Hall of the Cosmos Club, February 27, 1935, President SCHALLER, presiding.

*Informal communications.*—A. H. KOSCHMANN showed a slide illustrating a phenomenon very probably caused by pressure exerted by growing crystals. On Annette Island, Southeastern Alaska, pyrite crystals in a calcareous shale have tapering wedges of quartz on two and some on four sides. The longest pyrite-quartz crystal is 1.7 inches in length. Molds show that a film of quartz also completely surrounds the pyrite. The quartz shows no crystal outline and it is believed that the wedge-shaped openings now occupied by quartz were formed by the growing pyrite. Discussed by Mr. BEVAN.

*Program.*—L. G. HENBEST: *Cyclical sedimentation and the stratigraphy of the Bloyd shale, Morrow group, near Fayetteville, Arkansas.* The Bloyd shale around Fayetteville, Arkansas, contains three well known members, namely, the Brentwood limestone—at or near the base, the Baldwin coal—near the middle, and the Kessler limestone—about 50 feet below the top. The general character of the Bloyd shale has already been described and is generally known, but certain inconspicuous details of the stratigraphy have a historical significance that has escaped attention. This is particularly true of the sediments associated with the Baldwin coal.

The Brentwood limestone in this vicinity is typically massive in the lower part but grades upward into alternating marine marl and limestone beds. These marine beds are abruptly terminated above at a sharp, unweathered contact, above which lies 15 feet, more or less, of terrestrial, variously sandy shale. The top of the terrestrial shale is weathered and grades upward into the underclay of the Baldwin coal. The coal is followed by 0–5 feet of terrestrial, plant-bearing, carbonaceous shale and this in turn by a limy, conglomeratic, quartz pebble bearing marine sandstone, generally 5 feet or more thick. In northeast Fayetteville the limy sandstone is richly fossiliferous, but its original character is almost completely obliterated by weathering in the natural outcrops.

The stratigraphic succession described above is so closely similar to that which characterizes the Pennsylvanian cyclothems in Illinois that it may confidently be considered the same in origin. In certain respects the example near Fayetteville is even more suggestive of the opinion which the writer has held for some time that *the Illinois cyclothems were produced by saltatory but always downward movements of basins of deposition that were open to marine invasion as a consequence of each subsidence.* According to this hypothesis, each cyclothem appears to have begun with a relatively rapid and even depression of the basin, accompanied by a similarly rapid marine invasion and recorded by an advance marine deposit composed of macerated and decomposed plant material, mud, and remains of an advance marine fauna. A brief period of crustal stability followed and two different types of sedimentation (marine and deltaic) began simultaneously to fill the shallow basin and to force a slow retreat of the strand line. In marine areas that received little silt and afforded a normal marine fauna, limestone and limy marls were laid down, but in areas where large amounts of land-derived sediments were received and sudden, drastic changes in the composition of sea water were common, barren clays and silts were deposited. In such localities as the last, sporadic invasions of marine organisms or the drifting in of organic remains from land or sea furnished nuclei for subsequent formation of concretions, both calcareous and sideritic.

The rapidity and wide extent of the submergence that initiates the cyclothem is evidenced by the abrupt change from terrestrial to marine deposition, general absence of erosion at contact, and parallelism of the coal and marine beds. The subsidence which initiated the cyclothem was accompanied in all likelihood by uplift of adjacent positive areas. As a consesequence the streams were rejuvenated and began vigorously to degrade the uplands and to extend deltas into the basin, thereby causing a simultaneous migration seaward of the strand line and the zones of lime, marl, barren clay, and terrestrial deposition. The migration must have been interrupted or its record varied by exceptional floods, climatic cycles, biologic changes, shifts in ocean currents, or combinations of all or part of these.

The advancing terrestrial deposits were generally cross-bedded, channeled and filled, locally peaty, and generally characterized by great variation in composition, texture, and bedding structure. In their areas of alluviation the master streams or their distributaries evidently migrated from side to side as they advanced and in places cut deeply into or through their own sediments and into the preceding marine deposits, but they generally met strong resistance wherever they encountered the thick peat bed at the top of the preceding cyclothem. Inasmuch as the bottoms of the channels evidently were rarely or never exposed to air and as the channels were constantly migrating, the sediments beneath the intraformational unconformities were not weathered, therefore producing the fresh contacts which commonly are found in Illinois at this position. Back of the advancing front, the low-lying, poorly drained, alluvial plain became a favorable place for the formation of a soil (the *anlage* of most underclays), the growth of a lush flora, and the accumulation of peat if the climate was propitious. Locally, a veneer of plant-bearing clay or silt was deposited on the peat and ended the cyclothem record, possibly heralding the disturbance of land levels associated with approaching subsidence.

The dynamic background for this deformation is not clearly inferable at present, but circumstances strongly suggest a connection between the surface processes of simultaneous degradation and aggradation of adjacent areas and the periodicity of crustal yielding. Though covering thousands of square miles in some instances, the load of water-logged sediment composing a cyclothem rarely exceeded 50 to 125 feet, which is about one-sixth to one-twelfth the load supposed to be capable alone of causing an isostatic adjustment. In an area weakened by previous failures and enduring accumulating diastrophic stresses, a light load should be capable of hastening failure and promoting a more complete though temporary adjustment to the larger diastrophic forces at work in the region generally. Accordingly, isostatic adjustment is here regarded as an immediate, dynamic cause of the cyclothem and a factor whose importance as an agent promoting periodicity of deformation was much greater than the relative magnitude of its force. In relation to the more remote and fundamental causes of the extensive diastrophism of the time, isostasy was probably a sort of accessory-after-the-fact agent rather than a primary cause and possibly negligible at that.

The black, fissile, marine shale which overlies some coal beds and lies at the base of the cyclothem in which it occurs probably originated from bottom gel in the invading sea. This proposed origin for the fissile shale accounts for the association of macerated plant material, very fine to submicroscopic carbonaceous substance, and marine shells, and accounts for the finely lamel-

lar character of this shale. Except when strongly built, marine shells in these fissile shales are generally flattened by subsequent compaction of the sediments.

For practical and theoretical reasons the boundary between cyclothems is placed at the beginning of marine deposition above the coal zone instead of at the base of the advance, terrestrial deposits. (*Author's abstract.*) Discussed by Messrs. MISER, WILLIAMS, HENDRICKS, GILLULY, TRASK, SEARS, RUBEY.

Captain N. H. HECK: *Investigation of strong earthquake motions in California.* By means of earthquake maps of the earth as a whole and of the United States, the relation of earthquake activity in California was clearly brought out. A comprehensive attack on earthquake problems is now in progress, which, while primarily for the engineers, has many points of interest to the geologist. For the last two years, measurement of strong earth motions has been in progress by means of short period instruments known as accelerographs, long period instruments known as displacement meters (both types recording photographically) and visually recording instruments known as the Weed strong motion instruments. The present instruments are not capable of recording the strongest earthquakes that have occurred in California, but before long such instruments will be available. All of these are operated only during an earthquake. Features of the instruments include automatic starting and stopping (starting due to the earthquake itself), time marking, adequate damping, and naturally, low magnification.

Beginning with the Long Beach Earthquake, valuable records have been accumulated. Among those of special interest to geologists are those from the Long Beach Earthquake of March 10, 1933, which show changes in geological structures in different stations, a very different type of record obtained in the Imperial Valley, and records obtained in the same vicinity on several types of instruments. The latter has made it possible to determine the validity of a method of integration perfected by Mr. Frank Neumann of the Coast and Geodetic Survey, which among other things, brings out the fact that at the very starting of an earthquake and in the immediate vicinity of the epicenter, periods ranging from 15 seconds to nearly a minute occur.

Triangulation and leveling have been quite well extended in California to cover the principal areas where crustal movement is to be expected. A program with repetition of measurements at reasonable intervals has been developed. The possibility of tilting along major faults is being tested through tiltmeters at the University of California.

The various activities are made possible through regular and P. W. A. funds assigned to the Coast and Geodetic Survey. Cooperating agencies include the Carnegie Institution of Washington, California Universities, the Structural Engineering Organizations, Bureau of Standards and many others. None of the recent earthquakes have involved important geological changes, therefore the United States Geological Survey and similar organizations have not been required to take an active part in this particular program, but the need for such geological studies may come at any time. (*Author's abstract.*) Discussed by Messrs. RUBEY, TRASK, CALLAGHAN.

W. D. JOHNSTON, JR., and G. TUNELL, *Secretaries*

# SCIENTIFIC NOTES AND NEWS

*Prepared by Science Service*

## NOTES

*U. S. Naval Observatory.*—The greatest outburst of sunspot activity since last summer swept the sun recently, photographs obtained at the Naval Observatory indicate. Above the sun's equator, on what would be the northern hemisphere of the earth, a giant streamer extended from 47 to 82 degrees of longitude, or over one-sixth of the sun's diameter. The streamer's length was approximately 144,000 miles. In the southern solar latitudes were five separate groups of sunspots, some containing as many as three spots.

Coupled with the increased sunspot activity there was a succession of moderately severe magnetic storms, according to reports from the U. S. Coast and Geodetic magnetic station at Cheltenham, Md. "The storms," reports W. M. MCFARLAND, "seem to be a recurrence of the magnetic activity of late August and late July. There is often an interval of about 27 days between these recurrences, and sometimes such a group of magnetic disturbances will continue to occur for several years with this 27-day interval between the appearances. The present group of disturbances seems to have appeared first about two months ago."

*National Bureau of Standards.*—Dr. LYMAN J. BRIGGS, Director of the National Bureau of Standards, recently announced the formation of a new section for research on organic plastics. The increasing use of these materials by Government departments, coupled with a growing volume of requests for information, made a survey of their sources, properties, and uses imperative. Dr. GORDON M. KLINE, the chief of the new section, has been a member of the Bureau's staff for six years, during five of which he has been engaged in research on plastic materials.

Mr. RALPH W. SMITH of the weights and measures division of the National Bureau of Standards left Washington on October 6 to attend a meeting of weights and measures officials of the State of California in Los Angeles, October 16, 17 and 18. On November 6, 7, and 8 he will represent the Bureau at a meeting of weights and measures officers of the State of Michigan at Flint, Michigan. At the Los Angeles and Flint meetings Mr. Smith will speak on the activities of the National Conference on Weights and Measures with particular reference to specifications and tolerances for weighing and measuring devices.

Dr. MILTON HARRIS, the research associate of the American Association of Textile Chemists and Colorists at the National Bureau of Standards has returned from Europe where he visited the laboratories of the British Wool Research Association, the Shirley Institute for Cotton Research, the British Leather Manufacturers Association, and the Leeds University in England; and the Conservatoire National des Arts et Metiers in France.

*North American Council on Fishery Investigations.*—This organization held its 22nd meeting September 17 to 19, in the Department of Commerce Building. The Council is composed of the heads of fishery services in France, Newfoundland, Canada, and the United States, and eminent fishery scientists attached to their respective organizations. During recent years annual meetings have been held for the purpose of coordinating investigations of

the various countries in North Atlantic waters where fishermen from respective countries share in the sea fisheries of the region. Representatives of the United States Government were FRANK T. BELL, Commissioner of Fisheries; Dr. H. B. BIGELOW of the Woods Hole Oceanographic Institution, Chairman of the Council; and ELMER HIGGINS, Chief of the Bureau's Division of Scientific Inquiry. R. H. FIEDLER, Chief of the Division of Fishery Industries, and Messrs. O. D. SETTE, W. C. HARRINGTON, R. A. NESBIT, and JOHN R. WEBSTER of the Bureau's North Atlantic staff of biologists attended the meeting and participated by presenting reports on scientific investigations during the past year. Fishery experts of Newfoundland, Canada, and the United States presented technical reports on their investigations during the past year dealing with cod, haddock, mackerel, herring, Atlantic salmon, and other important species, and dealt extensively with improved methods of investigation regarding currents, temperatures, and chemical composition of sea water that affect the success of the various fisheries. Plans for collecting improved fishery statistics as a guide to industry were also developed.

At the close of the session the Council adopted a resolution calling upon the Government's representative to draft an international treaty for the protection of the great North Atlantic haddock fishery. Reports of investigators indicated that this fishery, worth to the fishermen more than four and one-half million dollars in 1933, is facing commercial destruction. U. S. Bureau of Fisheries investigators have demonstrated that a tremendous destruction of undersized, unmarketable fish occurs in trawl fishing. In some years this destruction has amounted to two-thirds of the total number of fish caught. Practical experiments at sea have shown that an increase in the size of the openings in the net from 3 inches as now used to 4¾ inches will permit the escape of the great majority of these young fish and thus reduce the strain of the fishery by more than one-half. On the basis of these findings the Council recommended to the governments of the nations concerned the drafting of a treaty to require the use of nets of larger mesh.

*National Park Service.*—VERNE E. CHATELAIN has been designated as Acting Assistant Director in charge of the Service's newly-established Branch of Historic Sites and Building, Washington Office. Authorization for establishment of this branch was contained in the 1936 Interior Department Appropriation Act.

Dr. FRITIOF M. FRYXELL, formerly of the Washington Office, has been transferred to the Service's Field Educational Division at Berkeley, California, where he will plan museum exhibits for western national parks.

BEN H. THOMPSON, special assistant to the Director, has returned to Washington Headquarters from the West, where he accompanied Director Cammerer and members of the Senate Committee investigating proposed national park sites.

KENNETH B. DISHER, is now connected with the Eastern Museum Division, Washington Office, lining up the Bureau of Reclamation Exhibit for the new Interior Department Building Museum. Mr. Disher came to Washington from the Chickamauga and Chattanooga National Military Park, for which area he planned museum exhibits. During the summer of 1934 he served as a ranger naturalist at Grand Canyon National Park and was stationed at the Wayside Museum.

*Asiatic grasses for the West.*—Erosion-checking grasses and other plants that can fight the droughts, winds and occasional floods of the Great Plains

area have been sought in Asia by three expeditions of the U. S. Department of Agriculture. Now, the explorers' work finished, the seeds and cuttings are being tested under field conditions at four stations in the West by agronomists. The expeditions were in Asia at various times during the past two years. One, under H. G. MACMILLAN and J. C. STEPHENS, collected in Manchuria. A second, under the direction of H. L. WESTOVER and C. R. ENLOW, traversed Russian Turkestan. The third, under Prof. NICHOLAS ROERICH, worked in northern China. The scientific spoils thus far checked number well over 2,000 lots of seed and planting stock, with some shipments yet to be accounted for. Among them are 798 grasses, 555 legumes and 889 miscellaneous items. By far the greatest number of packages received were in the Westover-Enlow collections.

### PERSONAL ITEMS

Surgeon-General HUGH S. CUMMING attended a meeting of the Health Committee of the League of Nations at Geneva, October 7 to 16, and also the sessions of the International Health Office in Paris, beginning October 17.

Commissioner FRANK T. BELL of the Bureau of Fisheries, U. S. Department of Commerce, was elected president of the American Fisheries Society, at its September meeting in Tulsa, Oklahoma. In attendance with Mr. Bell were R. H. FIEDLER, ELMER HIGGINS, TED LITTLE and H. S. DAVIS, of the Bureau.

Col. ROBERT BIRNIE, U. S. Army Ordnance Corps, retired, was awarded the Ordnance Medal of Merit by the Army Ordnance Association, in recognition of his pioneer work in gun design.

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## Obituary

FREDERICK L. RANSOME, economic geologist and a former president of the Washington Academy of Sciences (1918), died at his home in Pasadena, Calif., October 6, 1935. He was born at Greenwich, England, December 2, 1868. At the University of California he received the B.S. degree in 1893, the Ph.D. degree in 1896, and Phi Beta Kappa membership in 1910. From 1896 to 1897 he was assistant in mineralogy and petrography at Harvard University. In 1897 he joined the U. S. Geological Survey as assistant geologist and from 1912 to 1923 was geologist in charge of the section of metalliferous deposits. During the next four years he was professor of economic geology at the University of Arizona, and from 1927 until his death he held a similar position at the California Institute of Technology.

Doctor Ransome was active in many clubs and scientific societies, including the National Academy, Geological Society of America, American Association for the Advancement of Science, American Institute of Mining and Metallurgical Engineers, and Society of Economic Geologists. He was an associate editor of *Economic Geology* and the *American Journal of Science*. His numerous publications deal chiefly with the ore deposits and geology of western mining districts.